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Fatigue in Queensland's resources industry

Current state review



Resources
Safety & Health
Queensland

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Overview

Introduction

This report presents the findings of a review conducted by Resources Safety and Health Queensland (RSHQ) on the current state of fatigue risk management in the Queensland resources industry. The review was conducted throughout 2024 following a 2022 RSHQ resources industry occupational health risk prioritisation project, which highlighted opportunities to enhance RSHQ's understanding of the effectiveness of industry controls for managing fatigue. Furthermore, there were several road fatalities in recent years involving workers driving home after consecutive shifts, which highlighted an area where further insight was required. The objective of the review was to increase RSHQ's understanding of the effectiveness of industry's controls to manage fatigue risks to determine the need for any change in RSHQ's current regulatory approach or resource allocation for this hazard.

To achieve this objective, the review examined:

- the extent to which fatigue poses a risk across the Queensland resources sector, including intersectionality with other hazards
- the current regulatory approach applied to fatigue by RSHQ and in other jurisdictions
- benchmarks of effective contemporary fatigue management in resources and related industries.

A comprehensive review methodology was employed, integrating academic literature, incident and complaint data, regulatory frameworks, government resources, grey and white literature, and stakeholder consultations, including semi-structured interviews and forums.

Key findings

The review made 13 key findings.

A summary of these key findings has been provided in the following tables (**Tables 1.1 to 1.4**). Each table also includes the location in the report where the reader can find additional information and context on the subject.



Throughout this report a blue lightbulb has been used to highlight key findings or important takeaways (in bold blue text) that are relevant for decision-making. Whenever you see this icon, it signals a point that requires special attention or action, ensuring that the most critical insights are easily identifiable as you review the document.

Understanding fatigue

Fatigue is a complex state of impairment influenced by various factors such as inadequate sleep, extended wakefulness, demanding tasks, and emotional exhaustion.

Fatigue can be cognitive or physical, acute or chronic, and is often used interchangeably with terms like sleep deprivation. However, these terms fail to recognise fatigue's complex aetiology, including both personal and work-related contributors. Its subjective nature and variability among individuals make it challenging to define and measure consistently.

The interaction of these mechanisms, known as the *Two-Process Model*, governs the sleep/wake cycle. Variations in sleep requirements, disruptions from modern work demands, and individual differences in chronotype (morning or night preferences) further affect fatigue levels.

Fatigue is influenced by two key biological factors:



The homeostatic drive for sleep

Accumulates sleep pressure based on prior sleep and wakefulness.



The circadian rhythm

A 24-hour cycle that regulates sleep patterns and impacts body functions like temperature and hormones.

Impact and consequence of fatigue

Fatigue can manifest in a variety of ways, depending on the individual and the specific circumstances that have contributed to its accumulation.

Subtle signs of fatigue include excessive yawning, sore eyes, irritability, and muscle weakness. As fatigue progresses, impairment becomes more pronounced. Typically, in the work context, fatigue symptoms are considered based on their impact on job safety, including reduced attention, impaired decision-making, slower reaction times, and increased risk-taking.

The impaired cognitive functioning associated with fatigue can increase risk for near misses, incidents, and even fatalities. Workers may struggle to concentrate, misinterpret important signals, or fail to follow safety protocols. This is especially the case in high-risk industries and where long commutes are common practice.

Over time chronic fatigue can also lead to significant health issues, including obesity, heart disease, type 2 diabetes, high blood pressure, reproductive issues, and cancers. In 2007, night shift work involving circadian disruption was classified as a probable human carcinogen (Group 2A) (1). Epidemiological studies have linked long-term night shift work to an increased risk of several cancers, including breast, endometrial, prostate, and colorectal cancer (2). Prostate cancer incidence was found to be increased in the cohort examined through the *Queensland Coal Mine Workers' Cancer and Mortality Study*, as was colorectal cancer (3). However, breast cancer incidence was not increased.

Fatigue also increases the likelihood of anxiety, depression, substance abuse, and cognitive decline. A 2018 report for the Western Australian Mental Health Commission highlighted the link between poor mental health outcomes and fatigue in fly-in fly-out operations, noting greater psychological distress particularly among night shift workers (4). The link between fatigue and mental health were further explored in a 2022 report authored by the University of Queensland Sustainable Minerals Institute, finding that fatigue increased the risk of mental health issues and was exacerbated by psychosocial hazards. Improvements were seen in workplaces supporting adequate sleep and employee involvement in decision-making (5)



Fatigue causality

To develop effective strategies for managing fatigue, it is crucial to understand the causality, which can consist of both work-related and personal factors.

Identifying these causes is often challenging due to the complex and delayed relationship between exposure and health effects. Fatigue causes are multifaceted, involving sleep quality and quantity, personal factors relating to the individual such as presence of certain health conditions, and work scheduling strategies employed by the operator (**Figure 1**).

Good work design is critical in managing fatigue risks. Consideration of work design as it relates to fatigue, includes examination of scheduling practices, environmental conditions, physical and cognitive capabilities of the worker, the type of work performed, and the systems and processes that govern the work. These elements have the potential to disrupt the circadian rhythm and increase the homeostatic drive for sleep in workers. By applying the principles of good work design, the safety and health impacts of fatigue can be significantly reduced.

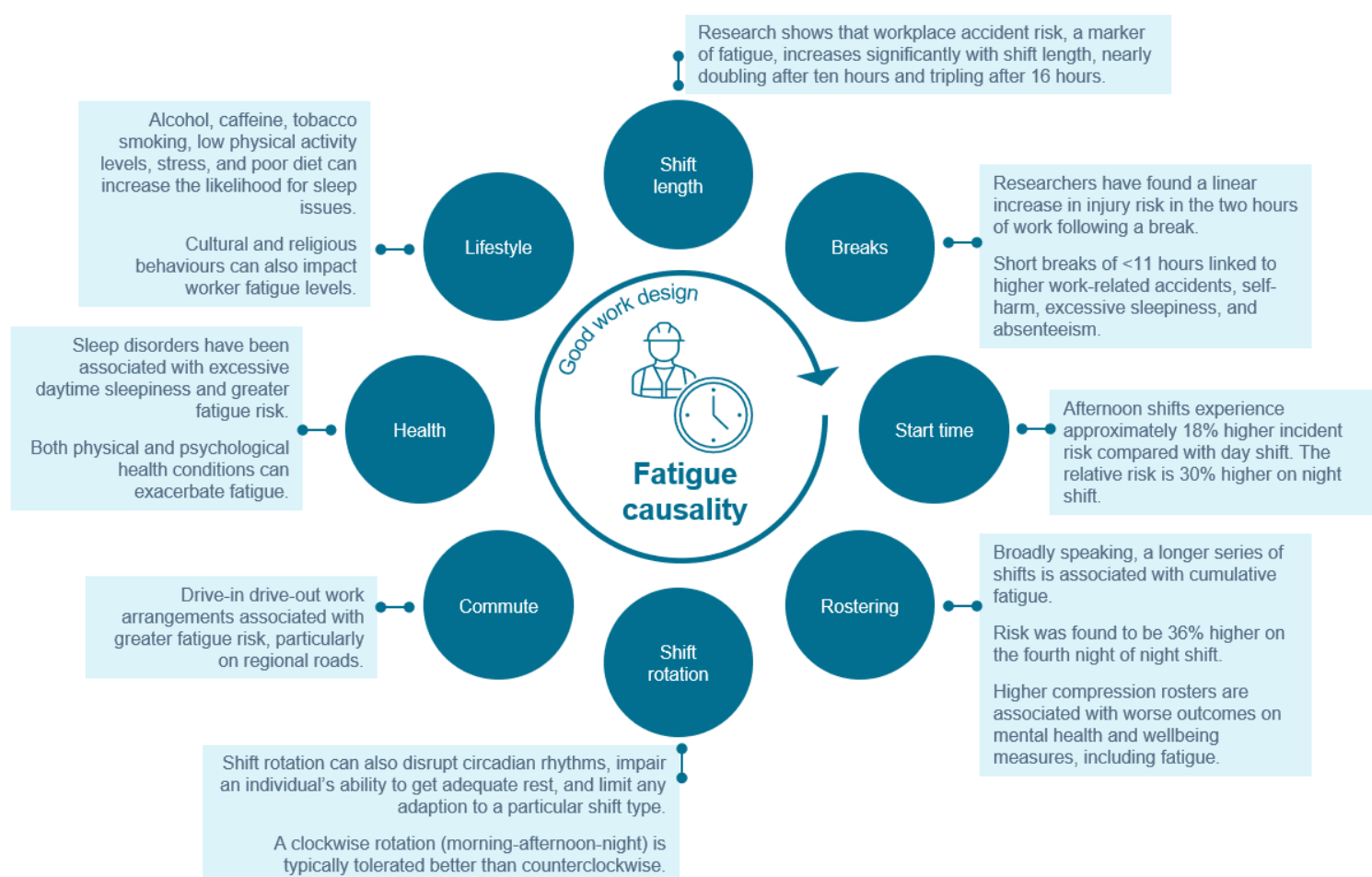


Figure 1 | Summary of fatigue causality, with brief descriptors of their contribution to fatigue and fatigue-related risk. Compiled from a variety of sources referencing research conducted primarily outside the resources industry.

Table 1.1 | Summary of key findings relating to **exposure to fatigue and fatigue risk factors**, with corresponding evidence and document locations.

Finding	Summary of supporting evidence	Location in document
Exposure to fatigue and fatigue risk factors		
Causality of fatigue is complex, including both work and non-work-related factors.	<ul style="list-style-type: none"> Determining the causes of health outcomes is often difficult as there is not always a linear, timely relationship between exposure and the harmful event. For health hazards such as fatigue, impacts may have a latency of years or even decades prior to manifesting. Given the difficulty in assigning causality, health hazards such as fatigue are typically poorly documented and inadequately acknowledged. Examining work design can unveil significant contributors to fatigue. Work scheduling plays a crucial role in influencing fatigue risk, impacting both physical and mental wellbeing. 	Section 4.0
De-identified ResHealth data suggests that a significant portion of coal mine workers may be at risk of sleep disorders and subsequent fatigue – further data and analysis is required.	<ul style="list-style-type: none"> De-identified ResHealth data reflects the collective findings of health assessments completed under the Coal Mine Workers' Health Scheme (CMWHS). Health risk factors, particularly overweight/obesity and high blood pressure, are associated with fatigue due to their influence on the development of sleep disorders. ResHealth data shows that for the just over 30,000 workers that completed a health assessment in the system from April 2023 to May 2024, 32% were found at examination to have a blood pressure reading regarded as high, and 22% were found to be in the overweight or obese category. 	Section 4.4
The mandatory health assessment for coal mine workers does not explicitly assess the worker's risk of fatigue, and how this may be impacting their fitness for duty.	<ul style="list-style-type: none"> The health assessment captures information that has relevance to the worker's fatigue risk profile including the worker's hazard exposure, use of personal protective equipment, medical history, anthropometric measures, consideration of the impact on lifestyle factors on fitness for duty, and consideration for other factors that may impact fitness for duty, e.g., shift work. However, it does not explicitly assess a worker's risk of fatigue or assist in identifying undiagnosed sleep disorders which may increase the risk of fatigue. The importance of assessing for undiagnosed sleep disorders was highlighted by several doctors at the RSHQ Doctor Workshop held in Brisbane in October 2024. The STOP-BANG screening tool for sleep disorders has been added to the 2024 revision of the <i>National Standard for Health Assessments of Rail Safety Workers</i>. 	Section 6.1.2
Consideration would be of value for how fatigue can be assessed in health surveillance or broader requirements around fitness for work for workers in the mineral mine and quarry	<ul style="list-style-type: none"> Mandatory health surveillance required for MMQ workers does not capture the breadth of health measures that is reported under the CMWHS, focusing solely on respiratory health. As a result, less inferences can be drawn regarding worker fatigue risk. Schedule 2E of the Mining and Quarrying Safety and Health Regulation 2017 (s. 5) requires the site senior executive (SSE) to arrange health surveillance for workers where exposure to a hazard could cause an adverse health effect. In addition, the SSE also has obligations to ensure 	Section 6.1.1 and Section 6.1.3

Finding	Summary of supporting evidence	Location in document
(MMQ) and petroleum and gas sectors.	<p>a worker is assessed to decide if their fitness level is adequate (s. 87).</p> <ul style="list-style-type: none"> • Within the <i>Petroleum and Gas (Production and Safety) Act 2004</i> (Qld), fatigue should currently be considered in the context of the operator's broader obligations to implement and maintain a safety management system (s. 674). Further, section 699 of the Act describes general obligations to keep risk to person or property to an acceptable level. • New South Wales (NSW) Coal Services administer the Order 43 medical, which uses the Epworth Sleepiness Scale (ESS) to screen for excessive daytime sleepiness, indicative of potential undiagnosed sleep disorder. This then prompts further investigations, including sleep studies. 	

Prevalence of fatigue

The Queensland resources industry, characterised by long shifts, irregular hours, and demanding conditions, fosters an environment where fatigue is likely to develop.

This is particularly true for labour hire and contractors who typically work longer, more sporadic hours compared with direct employees (6). Despite legislative requirements regarding consideration of contractors within the site's safety and health management system (SHMS) (or safety management system for petroleum and gas), in practice, contractors can be overlooked.

Despite fatigue being perceived as ubiquitous across the resources industry, challenges in measuring worker fatigue have led to limited data and a reliance on the use of incident rates as a proxy for understanding prevalence across the sector. Around 2.5% of notifiable incidents in the Queensland mining industry are attributed to fatigue, particularly in surface coal mines and heavy vehicle operations. Failing to recognise fatigue's role in incidents may contribute to an under-representation and an underestimation of the true impact from exposure. Workers' compensation data shows minimal recognition of fatigue as a contributing factor, with a relatively small number of accepted claims in the last five years.

The introduction of RSHQ's new Enterprise Operating System (EOS) incident reporting solution offers significant potential for improvement in understanding the nature and extent of exposure. By enabling detailed data capture via an online portal, this system enhances the ability to drill down on causality, encouraging more precise identification and management of fatigue by industry. The initial launch of the platform began in July 2023, involving 25 mine sites. Since the launch of the reporting system, 15 fatigue-related incidents have been reported (to July 2024). These are predominantly high potential incidents involving vehicle collisions, where the operator has reported experiencing a microsleep. As with the notifiable incident data explored previously, this number is likely to underrepresent actual incidents related to fatigue.

Table 1.2 | Summary of key findings relating to **the prevalence of fatigue incidents and complaints**, with corresponding evidence and document locations.

Finding	Summary of supporting evidence	Location in document
Prevalence of incidents and complaints		
Incident and complaint data capture and analysis for fatigue could be improved by enhancements to reporting mechanisms and complimented by education and competence building.	<ul style="list-style-type: none"> Challenges were identified in accurately extracting specific data from RSHQ's historical incident and complaint reporting systems. RSHQ's new EOS for online incident and complaint reporting will significantly improve oversight of fatigue management by enhancing data capture and to inform RSHQ's future regulatory activities. Further refinement of this system and education of the end user to ensure data quality, will help to build a robust fatigue data set. 109 complaints relating to 'fatigue' were made to the Mines Inspectorate from 2002 to 2024. The way complaints data was historically structured did not allow comparison of coal with mineral mines and quarries. Data from the Petroleum and Gas Inspectorate is stored in a separate database in a format that did not allow comprehensive analysis of fatigue related complaints or investigations. Fatigue's subjective nature and its complex causality make it challenging to definitively link fatigue to incident occurrence. While fatigue is often highlighted when microsleep is identified, in cases where human error plays a role without microsleep (e.g., unintended plant movement), fatigue may be less likely to be considered a factor. Other jurisdictions, including Western Australia and NSW do not make their incident data available in a format that allows comparison between jurisdictions. 	Section 3.1.1
An audit conducted by the Petroleum and Gas Inspectorate in 2021 highlighted important findings regarding the likelihood for fatigue.	<ul style="list-style-type: none"> The audit of two ancillary activity stakeholders (32 workers) found 25% of workers were at risk of fatigue, 72% were performing cognitively demanding tasks for long periods, 31% arrived at work fatigued, 41% had work hours that differed from their rostered hours, and 59% were required to be on-call or available outside rostered hours. Although this was a small pilot study, it underscored the need for further investigations. 	Section 3.1.1

Queensland regulatory context

Under Queensland resources legislation, fatigue is broadly captured through the SSE or executive safety manager's obligations to effectively manage the risks that arise through operations, ensuring risk to workers remain at an acceptable level. This is accomplished through the delivery of a SHMS, which is produced following consultation with workers. The coal framework is the exception with specific regulatory requirements related to fatigue and fitness for work. The SHMS includes an assessment of the level of risk, and implementation of appropriate controls to manage the risk.

The worker also has a requirement to comply with procedures and controls captured within the SHMS and not act in a way that might adversely affect the safety and health of anyone onsite.

Complexities arise when considering commuting, which can be interpreted to fall outside the jurisdiction of Queensland's resources legislation. The impact of commuting on worker fatigue and subsequent ability to work safely should be a key consideration under the broader safety and health obligations of the operator.

Commuting fatalities are generally investigated by the Queensland Police Service in the first instance. Where circumstances suggest work-related fatigue may have contributed to the incident, RSHQ will be notified. RSHQ investigations typically involve scrutiny of how fatigue is managed under the site's SHMS, and if controls outlined in the system were followed. Directives would be issued if problems were identified, however, specific historical data on directives issued relating to fatigue were not able to be obtained.

QGN16 Guidance Note for Fatigue Risk Management ('QGN16') published in 2013, provides guidance for managing fatigue risks in the mining and quarrying industries. Although QGN16 is non-statutory, sites have used it as a reference to meet their safety and health obligations relating to fatigue. Stakeholder engagement identified potential opportunities to review and update QGN16, including incorporating the latest contemporary evidence and industry best-practice. Feedback also included possible benefits of a recognised standard or guideline as opposed to a guidance note. This could create a stronger regulatory position for RSHQ to regulate fatigue related obligations across industry. However, given the inherent differences in application of fatigue risk management across sites and industries, it may prove challenging to develop a concise, practical, statutory recognised standard or guideline for fatigue.

Table 1.3 | Summary of key findings relating to **regulatory risk management**, with corresponding evidence and document locations.

Finding	Summary of supporting evidence	Location in document
Regulatory risk management		
There are opportunities to review and update QGN16, including incorporating the latest contemporary evidence and industry best practice. This could include consideration of potential benefits of a fatigue recognised standard or guideline, in lieu of QGN16.	<ul style="list-style-type: none"> Some stakeholders indicated that there may be opportunities to update QGN16 to ensure a more consistent and less-subjective application of the guidance material. This could also consider a greater focus on higher order controls. There was evidence that sites used QGN16 as a reference to develop their approach to fatigue risk management. Some stakeholders suggested that a statutory fatigue management regulatory tool (e.g., recognised standard or guideline) would apply more pressure on operators to address their fatigue risk compared with a guidance note. Industry representatives have suggested they are best placed to manage site-specific risks, and that fatigue management would not be improved through the creation of statutory fatigue management material. Feedback indicated that a worker's actual hours may vary significantly from planned hours. Like QGN16, most fatigue-related guidance material and codes of practice reviewed from across Australia utilise an element of prescriptive measures to ascertain fatigue risk. However, many caveat these resources as guidance material only, emphasising that scheduling decisions should be informed by the risk assessment process. 	Section 6.1.4

Finding	Summary of supporting evidence	Location in document
	<ul style="list-style-type: none"> Safe Work Australia is drafting a Code of Practice for the Management of Fatigue (to replace their guide currently in circulation). 	
A systems approach requires the evolution in thinking from a prescriptive, compliance-based approach to a dynamic, risk-based system in which the outcome is prioritised, underpinned by a framework that emphasises the shared responsibility of the worker and the operator.	<ul style="list-style-type: none"> A systems perspective recognises the complexity of interrelated factors that contribute to fatigue risk, emphasising the need for holistic solutions. By considering the entire work system—such as work schedules, environmental conditions, organisational culture, and individual health—this approach aims to identify and address root causes rather than isolated symptoms. Research has shown a trend towards the risk-based approach to fatigue management, away from prescriptive hours of service – the foundation of the fatigue risk management plan. In practice, application of a systems approach across industry is still on a spectrum between these two approaches, including the application of a hybrid model where elements of systems-based fatigue management are implemented alongside prescriptive rules relating to working hours and breaks. 	Section 7.1
Expansion of the Mining Hazard Database may help ensure controls provided reflect contemporary best practice.	<ul style="list-style-type: none"> Inclusion of fatigue in this database emphasises its relevance as a critical risk to be managed on site. The database includes several key fatigue-related risks and their mechanisms. This could be further enhanced to align with QGN16. The recent Omnibus Bill removed the obligation of RSHQ to maintain the Mining Hazards Database. As such, the future of the database is uncertain. 	Section 6.1.5
Further clarity may be beneficial regarding legislative safety and health obligations and jurisdictional boundaries relating to commuting, especially the journey home after a series of shifts.	<ul style="list-style-type: none"> Commuting has been recognised as a contributor to fatigue as well as a safety hazard resulting from fatigue. In Queensland, interpretation of the resources safety and health legislation primarily focuses on worker safety at the operating plant, mine site, or quarry (i.e., managing risks of fatigue at the worksite and individual fitness for duty to undertake work). As such, commuting, particularly the journey home at the end of a series of shifts, is often not considered under the legislative obligations of the worksite. This also means it has not been well documented, with limited data available on commuting incidents. Given the impact of commuting on worker fatigue and subsequent ability to work safely should be a key consideration under the broader safety and health obligations of the operator. Recent Supreme Court decisions may be of relevance in determining the view of the courts in relation to cases that involved driving after a series of night shifts. 	Section 6.1.7
Whilst historical data was difficult to analyse, RSHQ's new reporting system will enable further trend analysis to inform a risk-based approaches for fatigue related	<ul style="list-style-type: none"> 74 Mine Record Entries (investigations) were issued by the Mines Inspectorate between 2015 and 2023 relating to fatigue. A mines safety bulletin (no. 163) published in 2017, references Coal Mines Inspectorate investigations involving roster changes, contract arrangements and hours of work arrangements. 	Section 6.1.6

Finding	Summary of supporting evidence	Location in document
regulatory interventions. There are opportunities to enhance the capability of inspectors regarding fatigue risk management regulation.	<ul style="list-style-type: none"> Feedback from inspectors indicated that fatigue may be overlooked as a causal factor in incident reports. As such, many investigations would not specifically examine fatigue risk management on site. Commuting injuries or fatalities are currently not required to be reported via statutory reporting mechanisms and are often recorded as a non-reportable event. As a result, there may not be thorough consideration if fatigue was a contributing factor and if so, whether the site was effectively managing fatigue risks that may have contributed to the incident. Historical systems data was difficult to analysis effectively to inform data-driven, risk-based regulatory action. RSHQ's new EOS for online incident and complaint reporting will significantly improve data capture and trend analysis to inform RSHQ's future proactive regulatory activities. Feedback from inspectors suggested opportunities to increase internal capability could support consistent and contemporary regulation of fatigue risk management. 	

Other jurisdictions

Various industry guidelines, codes of practice and regulatory frameworks are employed to manage fatigue across jurisdictions outside of the Queensland resources industry. Consistent across jurisdictions is the recognition of fatigue as a hazard and the shared responsibility between operators and workers to manage fatigue. Amongst regulators, there is a trend away from a reliance on prescriptive hours of work, towards a risk-based approach to fatigue management recognising the systemic factors that contribute to the likelihood of exposure to this hazard. This approach aligns better with legislative requirements for integrated SHMSs, while also providing an element of flexibility and adaptability that is needed to adequately respond to fatigue risk.

Management of fatigue risk

Fatigue risk management is crucial for worker safety in high-risk industries like mining, quarrying and petroleum and gas, where long hours and shift work are common. An effective fatigue risk management plan uses data-driven practices to identify and control fatigue-related risks. It provides specific measures to manage these risks and integrates with broader safety management systems. By aligning with existing safety procedures, the fatigue risk management plan enables a cohesive approach to risk management, reinforcing safety culture, implementation of best practices and compliance with regulatory requirements. This integration helps to create a strong safety framework that addresses fatigue prevention from a risk perspective rather than ad-hoc compliance with hours of work.

Despite a site having robust fatigue risk management systems in place, it is not uncommon for actual hours worked to diverge from those initially planned. This discrepancy can arise due to unforeseen delays, increased workload, or operational demands that require extending shifts beyond what was scheduled. Such variations often lead to increased fatigue levels among workers, potentially undermining the effectiveness of the fatigue management strategies and impacting overall safety and productivity. Addressing these inconsistencies, including working with Human Resources to obtain relevant working hours data, requires ongoing monitoring

and adjustments to ensure that fatigue risk is effectively managed in real-time. Addressing fatigue requires a holistic approach that includes recognising its impact on safety and performance, as well as worker wellbeing, and implementing effective strategies to manage and mitigate its effects

Risk management approach Apply a risk management approach to identify suitable controls for identified risk factors.	
Effective scheduling practices A crucial component of work design and important variables to consider when managing fatigue. Manipulating elements of shift length, rest breaks, start times, and shift rotation can contribute to or alleviate worker fatigue.	Worker accommodation Should be designed to maximise sleep opportunity and support social connectedness.
Leveraging technology In-vehicle monitoring systems, wearables, and mobile apps used to track fatigue indicators, automate hazardous tasks, and support worker safety. Although these technologies help reduce fatigue incidents, they act as a mitigating control rather than preventative control, and as such, should complement rather than replace comprehensive fatigue risk management programs. Issues such as privacy, cost, and maintenance also need to be addressed.	Napping Can be an effective fatigue management strategy if carefully applied.
	Timely exposure to light Can have an immediate positive impact on alertness, contributing to worker adaptation to night shift.
	Environmental conditions Can accelerate exhaustion and fatigue. Managing environmental conditions, such as through providing adequate ventilation in hot or humid conditions, is an important strategy to address associated fatigue.
Sleep hygiene practices Individual strategies to improve the quality and quantity of sleep obtained, including creating an environment conducive to sleep, avoiding the use of alcohol or caffeine prior to sleep, and maintaining a consistent sleep/wake cycle.	

Figure 2 | Fatigue control categories, summarising the broad range on controls that sites may implement.

Table 1.4 | Summary of key findings relating to **industry's approach to managing harm**, with corresponding evidence and document locations.

Finding	Summary of supporting evidence	Location in document
Industry approach to managing harm		
With advances in technology, it has been suggested that a system to track contractor movements between sites be explored again, potentially with the use of QR codes.	<ul style="list-style-type: none"> Contractors have been highlighted as a greater risk from a fatigue management perspective due to their unpredictable hours and regular movement between sites. Some sites have a process to review a contractor's seven-day work history prior to allowing them on site. At an industry level, the coal industry has previously implemented a passport system for contractors moving between sites. Although this raised awareness of the total hours contractors were working, it relied heavily on an honesty system and was ultimately unsuccessful. Note the Coal Mining Safety and Health Committee have reportedly commenced work exploring this issue. 	Section 7.3
The availability and adequacy/ suitability of accommodation facilities (worker	<ul style="list-style-type: none"> Concerns regarding accommodation facilities centre around poor design that impacts sleep, shared facilities, isolation (lack of reliable access to internet and phone 	Section 7.8.2

Finding	Summary of supporting evidence	Location in document
camps) has been raised as a significant contributor to fatigue risk.	<p>services), lack of recreation facilities, and poor quality of food provided.</p> <ul style="list-style-type: none"> A notable issue for workers is the insufficient availability of beds before they commute at the end of their roster. Industry as well as union have both expressed concerns with accommodation facilities for resources industry workers. 	

Stakeholder engagement

For the current state review, a range of stakeholders from diverse groups were engaged informally through forums and one-on-one interviews to gather valuable preliminary insights. Participation was voluntary and dependant on stakeholder availability. A summary of stakeholder feedback is provided in **Table 2**.

Table 2 | Stakeholder engagement and notable perspectives, observations or comments.

Stakeholder	Engagement approach	Findings
Former Resources Safety and Health Commissioner (Andrew Clough)	In May 2024, the Commissioner led a forum hosted by the Coal Mining Safety and Health Advisory Committee (CMSHAC), which focused on fatigue management in the coal mining industry. Following this, the Commissioner participated in several industry forums, where fatigue was discussed, and attended a meeting with RSHQ to discuss further details regarding fatigue management across the sector.	<ul style="list-style-type: none"> Recognises fatigue as a critical safety and health issue in the resources sector, one that directly impacts workers' wellbeing and operational safety. Has commenced work on several fatigue projects, e.g., investigating a contractor tracking system, following the CMSHAC forum. Expressed a willingness for the Commissioner's office to work with RSHQ on future fatigue projects where possible.
Industry	<p>The Queensland Resources Council reached out to its members on behalf of RSHQ, inviting them to participate in discussions on fatigue management. Several companies took up this opportunity. In addition, some companies had publicly available information (abstracts and conference proceedings) that could be referenced through the review.</p> <p>Safer Together also participated in an interview.</p>	<ul style="list-style-type: none"> Fatigue recognised as a critical risk and managed as such. Systems may be in place but individuals not adhering, e.g., electing to drive home at the end of a series of night shift rather than rest for minimum number of hours – culture an issue. Increased use of technology, but limitations around its use (in coal). Undertaking sleep disorder screening (predominantly pre-employment) and individual fatigue assessments with workers (ongoing). Camp accommodation an issue. Require expertise to conduct accurate and informed fatigue risk assessment – may require external expertise if not available in-house.
Mining and Energy Union	Attended CMSHAC fatigue forum in Emerald in May 2024 and invited RSHQ to attend the SSHR conference in June 2024	<ul style="list-style-type: none"> Preference for a fatigue recognised standard to allow greater enforcement by regulator and to enhance importance of fatigue management on site. Concerns regarding adequacy and availability of accommodation and fatigue rooms.

Stakeholder	Engagement approach	Findings
	where fatigue was on the agenda.	<ul style="list-style-type: none"> The MEU advised RSHQ that they were planning to undertake a fatigue “campaign” in 2025, including conducting a series of site audits focused on fatigue risk management within SHMS.
RSHQ	Informal requests were sent across the inspectorates to identify inspectors with specific experience in fatigue who were available for one-on-one discussions. Presentations were also provided to the RSHQ Board, CAPU IR team, MMQ South, and the RSHQ Workplace Health and Safety Steering Group.	<ul style="list-style-type: none"> QGN16, both positive and constructive. Camp conditions a significant consideration and contributor to fatigue risk. Fatigue culture an issue – complacency and normalisation. Drive-in drive-out biggest risk for remote workers. Journey management plans often not well utilised. Smaller operators considered higher risk cohort due to lack of knowledge, resources and systems to address fatigue risk. Inspectors balance other safety and health priorities, which impacts capacity to address fatigue on site. One-size-fits-all approach to managing fatigue risks not appropriate.
Safe Work Australia	Meeting.	<ul style="list-style-type: none"> Discussions regarding the drafting of the model Code of Practice: Managing fatigue risks at work. Opportunity to provide feedback on the draft Code of Practice.
Other regulators	Including the Office of Industrial Relations Queensland, WorkSafe Victoria, and the National Heavy Vehicle Regulator (NHVR).	<ul style="list-style-type: none"> The NHVR are working to provide industry with the skills and expertise to contextualise safety management systems to fatigue rather than rely on prescriptive measures of compliance. This included internal upskilling as well as extensive industry consultation. Specific training provided to inspectors. Other regulators observed that fatigue often overlooked when obligation holders conduct investigations – actively working to address this.
Resources Medical Advisory Committee	Fatigue presented at the May 2024 RMAC meeting.	<ul style="list-style-type: none"> Members provided a variety of references to include in the review. Discussions regarding approach to highlighting the complexity of fatigue aetiology.
Doctors performing statutory health surveillance	RSHQ workshop held on 12 October 2024 for doctors registered to perform health surveillance on mining and quarry workers in Queensland.	<ul style="list-style-type: none"> Concerns around undiagnosed sleep disorders and how this could potentially be captured in the existing health assessment framework. Acknowledged the complexity of fatigue and the broad range of factors that contribute to fatigue.

Concluding remarks

This review of fatigue management in the Queensland resources industry highlights the multifaceted nature of fatigue and its considerable impact on worker safety, health, and productivity. The findings underscore the complexity of managing fatigue, influenced by both personal and work-related factors, as well as the variability in its recognition and reporting. While current regulatory frameworks provide a foundation for addressing

fatigue, there is an opportunity for enhancements through developing contemporary data collection and reporting systems and implementing a proactive approach to audits and inspections. This approach may inform future potential updates to the guidelines. Appropriate use of a fatigue risk management plan by industry, as part of the site's SHMS, will also drive fatigue risk management forward. The introduction of innovative fatigue management practices, including the use of technology, offer additional promising avenues for reducing fatigue-related incidents. The key findings highlighted through this report can be considered by RSHQ to inform RSHQ's regulatory approach to ensure risks of fatigue are managed effectively.



Introduction and background

This report represents the findings of a current state review of fatigue management in the Queensland resources industry undertaken by Resources Safety and Health Queensland (RSHQ). This report has been prepared throughout 2024 and early 2025 following a resources industry occupational health risk prioritisation project completed in 2022, which identified opportunities to enhance RSHQ's understanding of the effectiveness of regulatory activities and industry controls for fatigue (7).

Over recent years, several road fatalities involving resource sector workers driving home after completing consecutive shifts also highlighted an area where further insight on the impact of fatigue was required. These incidents have sparked broader discussions about how effectively the industry is managing the associated risks, particularly in terms of worker safety, shift scheduling, and the adequacy of fatigue management strategies.

The objective of this review was to increase RSHQ's understanding of the effectiveness of industry's controls to manage fatigue risks to inform future regulatory activity decisions. To achieve this objective, the review examined:

1. The extent to which fatigue poses a risk across the Queensland resources industry, including intersectionality with other hazards.
2. The current regulatory approach applied to fatigue by RSHQ and in other jurisdictions.
3. Benchmarks of effective contemporary fatigue management in resources and related industries.

A multifaceted methodology was applied, incorporating academic literature, regulatory frameworks, government resources (e.g., guidelines and codes of practice), grey and white literature, and stakeholder consultation (including semi-structured interviews and forum participation). Consultation and engagement were undertaken with the following stakeholders:

- Resources Safety and Health Commissioner
- Other regulators, including the Office of Industrial Relations Queensland, WorkSafe Victoria, and the National Heavy Vehicle Regulator
- Safe Work Australia
- Industry, including the Queensland Resources Council and Safer Together
- Resources Medical Advisory Committee
- RSHQ inspectors and hygienists, including the Serious Incident Investigation Unit
- Members of the RSHQ Central Assessment and Performance Unit (CAPU) Incident Response team
- New South Wales Coal Services.

1.0 What is fatigue?

Fatigue is a state of impairment caused by inadequate sleep (quality or quantity), extended wake, time on task, emotional exhaustion, or circadian disruption (2) (8).

It is important to recognise that fatigue exists on a continuum and is not a discrete state or outcome. It is highly individualised and subjective making it difficult to uniformly describe and measure. The extent of impairment due to fatigue can be influenced by environmental conditions, along with personal factors such as lifestyle and stress levels.

The definition of fatigue can be extended to include consideration for how work tasks impact fatigue levels (9). *Active fatigue* can occur when the worker performs high levels of physically or cognitively demanding activity. By contrast, *passive fatigue* can occur with extended periods of monotonous activity (10) (2). Expanding on aetiology, fatigue can be further classified as cognitive or physical, with cognitive fatigue occurring based on the mental or emotional workload required and physical fatigue occurring based on the physical load required (11). Fatigue can also be described as either acute or chronic, based on the timing of sleep restriction (2). Acute or 'transient' fatigue originates from extreme sleep restrictions in a short length of time (9). Chronic fatigue typically results from insufficient sleep over a longer period.

The use of terminology around fatigue is somewhat ambiguous, with some using 'sleepiness' and 'drowsiness' interchangeably with 'fatigue', while others classify these as separate states. Sleep deprivation and fatigue are also often used synonymously. Northern Territory WorkSafe (2023) describes drowsiness or sleepiness as the urge to fall asleep as a result of a biological need following absence of sleep, which captures the driver of fatigue, but does not fully articulate the complexity of this condition (12). Fatigue, sleep deprivation, and drowsiness can ultimately have similar significant safety implications, but fatigue encompasses a broader state, with diverse contributing factors, and health and safety outcomes.

1.1 Physiology of fatigue

Fatigue is a function of the interaction between two major biological factors, the homeostatic drive for sleep and the circadian rhythm (**Figure 1**) (2). These two mechanisms interact to regulate the sleep/wake cycle, known as *the two-process model* (13).

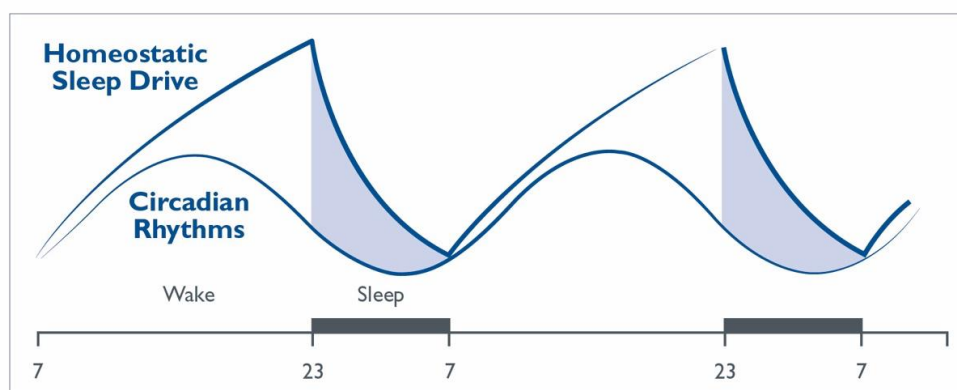


Figure 1 | Physiological drivers of sleep regulation (the two-process model) (13).

The homeostatic drive for sleep is the sleep pressure that an individual experiences based on the amount of sleep they have recently obtained, and the time elapsed between sleep periods. When an individual is awake for an extended period and insufficient sleep is achieved, it creates sleep deprivation and a 'sleep debt'. This sleep debt can accumulate, increase sleep pressure, and lead to fatigue (10). Research suggests adults between 18 and 64 years of age should be achieving between seven and nine hours of sleep per night (14) (15). However, there are substantial individual differences in sleep requirements and fatigue tolerance, as well as a normalisation of sleep debt that is perceived as tolerance (2). Only approximately 1% of the population can function well on less than five hours of sleep (11).

The circadian rhythm is the physiological programming for sleep, repeated every 24 hours (10). Several body functions are impacted by the circadian rhythm, including body temperature and hormones, particularly the 'sleep hormone' melatonin (16). The circadian trough or *nadir* typically occurs between two and six in the morning, when body temperature drops, melatonin levels rise, and sleep pressure is greatest (13). This period is also associated with an individual's lowest cognitive and physical performance. Following this, body temperature rises, melatonin declines, and sleep propensity drops until reaching the *circadian acrophase* or peak (2) (16). Highest physical and cognitive function are experienced during this stage of the cycle. There is another, less pronounced circadian nadir between 2pm and 4pm (10).

Humans are diurnal creatures, meaning they are not adapted to extended periods of wakefulness, nighttime work, and substantial changes in the sleep/wake cycle (2). However, given the rising prevalence of shiftwork, fly-in fly-out (FIFO) or drive-in drive-out (DIDO) operations, and 24-hour production, disruptions to the sleep/wake cycle are inevitable.

An individual's circadian rhythm is also closely related to their chronotype (17). Chronotype, or diurnal preference, refers to an individual's natural preference for being active and alert at certain times of the day. The physiological flow of the circadian rhythm may predispose an individual to be a 'night person' (a 'night owl'), or a 'morning person' (a 'lark'). In reality, chronotypes fall on a spectrum, with most people lying somewhere in between (18). An individual's chronotype can also change as people age, reflecting natural changes in the circadian rhythm as we age. The tendency to perform better at certain times of the day can have a profound impact on an individual's personal and professional life.

It is widely accepted that for most people **less than five hours sleep in the 24-hour period prior to starting work, less than 12 hours in the 48 hours prior, or being awake longer than the amount of sleep obtained in the 48 hours prior** to starting work is going to significantly disrupt the physiological drivers for sleep and contribute to fatigue risk.

(Dorrian, Baulk, and Dawson, 2011)

1.2 Signs and symptoms

Fatigue can present as both physical and/or cognitive impairment, with impairment proportionate to the level of sleep pressure and circadian disruption an individual experiences (2). Discussions around fatigue symptoms typically focus on those relating to the safe performance of job tasks, such as reduced attention and vigilance, impaired decision making ability, increased reaction times, increased tendency for risk-taking, reduced

communication ability, impaired concentration and memory, and an inability to stay awake (microsleeps) (19) (2) (10). This focus on safety-related impacts of fatigue is well justified, with research indicating that the likelihood of incidents nearly doubles after a 10-hour shift compared to an eight-hour shift and tripling after a 16-hour shift. (19).

There are also many subtle signs that an individual may be experiencing fatigue. These include long eye blinks, excessive yawning, fidgeting and squirming in seat, sore eyes, lack of motivation, irritability and other mood changes (poorer emotional regulation), headaches, and muscle weakness (19) (2) (10).

A longer-term outcome of fatigue is the development of health issues, associated with chronic circadian rhythm disruption. The following section delves deeper into these signs and symptoms, highlighting the extensive impact fatigue can have on individuals.

2.0 Impact of fatigue

2.1 Impaired cognitive and physical performance

Research has consistently demonstrated that fatigue leads to measurable impairments in both cognitive and physical performance (13). A pivotal study from 1997 revealed that 17 to 19 hours of continued wakefulness produces performance deficits equivalent to a blood alcohol concentration of 0.05% (20). Since then, extensive research has been conducted on the effects of fatigue on cognitive and physical performance across diverse settings, including the workplace. This impairment is particularly evident during the transition to daylight saving time when clocks are rolled forward. Studies show that safety incidents, such as workplace injuries and car accidents, increase by 6% to 30% on the day daylight saving time begins (21).

The cognitive and physical performance impairments associated with fatigue has been quantified in terms of the relative risk of workplace incidents across shift patterns (2). Relative risk of workplace incidents on shifts starting between 1400 h and 1800 h increase approximately 18% compared with day shift. Shifts starting between 1800 h and 0400 h translated to an approximate 30% increased relative risk. This will be explored further in [Section 4](#).

2.2 Physical health impacts

Long-term studies conducted both nationally and internationally indicate that inadequate sleep plays a role in the onset of chronic health conditions (2) (10). Fatigue has been associated with an increased risk of:

- obesity (due to impaired appetite control and hormonal disruption, and reduced physical activity)
- heart disease
- type two diabetes
- high blood pressure
- gastrointestinal disorders
- reproductive issues, including reduced fertility, a greater frequency of miscarriages and impaired foetal development
- infectious diseases such as colds, influenza, and shingles.

Studies in Australian adults with obstructive sleep apnoea, who are in a state of chronic sleep deprivation, were found to have 8.8 times higher likelihood of experiencing two or more chronic health conditions compared to those without obstructive sleep apnoea when controlling for age, gender, body mass index, smoking, and daytime sleepiness (22).

2.2.1 Carcinogenicity

In 2019, the International Agency for Research on Cancer (IARC) classified night shift work involving circadian disruption as a probable human carcinogen (Group 2A), underscoring the need for further research and preventive measures to mitigate exposure (1). Research has indicated that the misalignment of the circadian rhythm, often experienced by individuals working irregular hours, can lead to alterations in hormone levels, immune function, and cell cycle regulation, all of which are critical factors in cancer development. Epidemiological studies have linked long-term night shift work to an increased risk of several cancers, including breast, endometrial, prostate, and colorectal cancer (2). Interestingly, prostate cancer incidence (when controlled for age and smoking status) was found to be increased in the cohort examined through the Queensland Coal Mine Workers' Cancer and Mortality Study (3). As was colorectal cancer, particularly within blast crews. However, breast cancer incidence was not increased.

2.3 Psychological health impacts

Fatigue not only increases risk of physical health conditions but also increases risk of anxiety, depression, substance abuse, and suicide (10) (2). For example, insomnia, leading to disrupted sleep patterns, has been associated with more than twice the risk of depression (22). Chronic sleep deprivation has also been linked to cognitive impairment and greater cognitive decline over the lifespan due to the association between sleep and neural plasticity (23).

A report produced for the Western Australian Mental Health Commission in 2018 highlighted the link between poor mental health outcomes and fatigue in the context of FIFO operations (4). The authors identified that poor sleep associated with FIFO work patterns was also associated with greater psychological distress compared to benchmark groups. This effect was notably worse for night shift workers, and on the workers' transition from work to home where the joy of returning home was 'dampened' by fatigue. The toll of shift work and long hours, such as changes to energy levels and mood, were transferred from the workplace to home, and consequently had a negative impact on both work and family relationships (5).

The link between fatigue and mental health were further explored in a 2022 report authored by the University of Queensland Sustainable Minerals Institute (23). The authors found that fatigue directly increased the risk of mental health issues in workers. They also noted that psychosocial hazards, like limited control over work schedules or high job demands, had a compounding negative impact on the worker's health and fatigue levels. Conversely, workplaces that supported adequate sleep and involved employees in decision-making showed improvements in both mental health and fatigue levels.

2.4 Operational impacts

Fatigue can also have an impact from an operational business perspective. A North American study found mining shovel operators to be 3.2% slower in terms of dig rates (11). Similarly, haul truck operators had a 3.3% slower spot time when affected by fatigue. In a study of Australian rail operators, fatigue-impacted workers were found to use 9% more fuel than rested drivers (13).

2.5 Case law

In Australia, case law has established significant precedents regarding work-related fatigue and its implications for employer liability. One notable case is *Koehler v. Cerebos (Australia) Ltd* (2005) 222 CLR 44, where the High Court of Australia addressed the issue of employer responsibility for work-induced stress and fatigue. The court ruled that employers have a duty of care to ensure that their employees are not exposed to unreasonable risks of harm, including those arising from excessive workload and fatigue. This decision underscored the importance of employers implementing effective risk management strategies to mitigate fatigue-related risks in the workplace.

In the same year, another fatigue-related case was heard in New South Wales (NSW), *Matinca v Coal & Allied Mining Services Pty Ltd* [2005] NSWCA 300. The New South Wales Court of Appeal ruled in favour of Mr. Matinca, who suffered injuries due to work-related fatigue. The court found that the employer had breached its duty of care by failing to implement effective fatigue management strategies.

Fatigue has also been addressed more recently, including in the Supreme Court of Queensland case *Kerle v BM Alliance Coal Operations Pty Limited & Ors* [2016] QSC 304. The plaintiff, Mr. Kerle, was a labour hire coal miner who suffered serious injuries in a motor vehicle accident after finishing a 12-hour night shift. The court found that the employer had breached its duty of care by failing to adequately manage the risks associated with employee fatigue. What was particularly significant about this case is that both the operator (BM Alliance) and Mr Kerle's employer were found to share responsibility.

More recently, a Victorian warehousing and logistics company and the company director have been charged following the death of a delivery driver (24). The company and its director allegedly failed to ensure the worker took adequate stationary rest breaks and time out of the vehicle. The matter was listed for hearing on 2 August 2024 – an update is not available at the time of completing this report.

In addition to case law findings, the Queensland coroner's inquest into the deaths of Graham Brown, Malcolm Mackenzie, and Robert Wilson has been a critical investigation into the role of work-related fatigue in road fatalities (25). A joint inquest was held following two separate car accidents involving Graham Brown, Senior Constable Malcolm Mackenzie, and Robert Wilson, where driver fatigue was suspected to be a contributing factor. In both accidents, the drivers were commuting home after shifts at a mine in the Bowen Basin when their vehicles crossed into the opposite lane and collided with oncoming cars. The inquest detailed measures aimed to prevent similar incidents in the future.

3.0 Prevalence of fatigue

Similar to psychological concepts such as intelligence, fatigue is not currently directly measurable but rather inferred from observed connections between causal or contributing factors and their effects (26). As such, consistent, robust data on the prevalence of fatigue is limited and heavily relies on self-reported data.



13% of injuries
(approx.) in all workplaces likely to involve fatigue (99).

Most publicly available statistics regarding fatigue originates from datasets related to road safety. Sleepiness contributes to 20-30% of all deaths and severe injuries on Queensland roads (27). Rates are higher among male drivers, with research showing men to be disproportionately represented (75%) in single vehicle crashes. Young adults are also at greater risk, with almost two thirds of sleep-related crashes involving young adults. Rural drivers, shift workers, FIFO and DIDO workers, on-call workers, and people with underlying medical conditions were also at greater risk (27) (10).

The *Queensland Coal Mine Workers' Cancer and Mortality Study* found rates of accidental death, including transport accidents, to be higher than the Australian population, but on par with Queensland rates (3). It was noted that 59% of accidental deaths were a result of transport accidents, however, it was not clear how many of these deaths occurred in work time or when commuting to or from work. Accidental deaths were higher for men who had ever been production workers or truck drivers, compared with other men, and the risk was higher for men within five years of their first assessment under the Coal Mine Workers' Health Scheme and decreased for those with longer tenures in the industry.

Studies specifically examining driver fatigue in the Australian coal mining industry found that 13% of participants reported falling asleep at the wheel while driving to the site, and 43% reported doing so when driving home, with 3% of these workers being involved in a road incident (23).

3.1 Fatigue in the Queensland Resources industry

The demanding nature of the Queensland resources industry, characterised by long shifts, irregular working hours, extreme environmental conditions, and the physical intensity of tasks, are all conducive to fatigue accumulation (9). The 2021 ABS census found mining to be the industry with the highest proportion of workers working more than 50 hours per week (28).

The *2019 Brady Review of fatal accidents on Queensland Mines and Quarries* identified one fatality, from the 47 total, possibly caused by worker fatigue (29). However, fatigue-related fatalities could be considerably higher if reporting mechanisms considered work-related fatigue as a contributing factor (see [Section 6.1.7](#)).

On average, between 2015 to 2019, approximately 12% of lives lost on Queensland roads were from fatigue-related crashes (30). When examined from a regional perspective, in the Mackay district this climbed to one-third of fatal road accidents. This suggests some link with the specific characteristics of the region. Road conditions and long driving distance are likely contributing factors, but it would be naive to suggest that worker fatigue does not also have a part to play.

3.1.1 High potential incidents

A preliminary search of RSHQ’s historical lotus notes High Potential Incident (HPI) Database using the terms ‘microsleep’, and ‘micro-sleep’, identified a total of 329 incidents in the ten years to 2023. Extracting all incidents related to fatigue from the database was difficult due to the use of various synonyms for fatigue in the reports. Additionally, it was necessary to manually filter out cases of ‘material fatigue,’ which skews the accuracy of the results. Most incidents identified (304, 92%) were reported to the Inspectorate by organisations in the coal industry, with 25 reported from mineral mines and quarries (**Figure 2**). A review of incident data submitted to the Petroleum and Gas Inspectorate from 2018 to 2024 did not reveal a single event explicitly related to fatigue. Discussions with Inspectors regarding fatigue investigations highlighted the large potential for under-representation. Fatigue is often only considered as an ancillary contributing factor to incidents, despite potential significant contribution. For example, if a rollover incident occurred on site, this would likely be investigated as an unplanned movement of plant, not fully appreciating the contribution fatigue could have made.

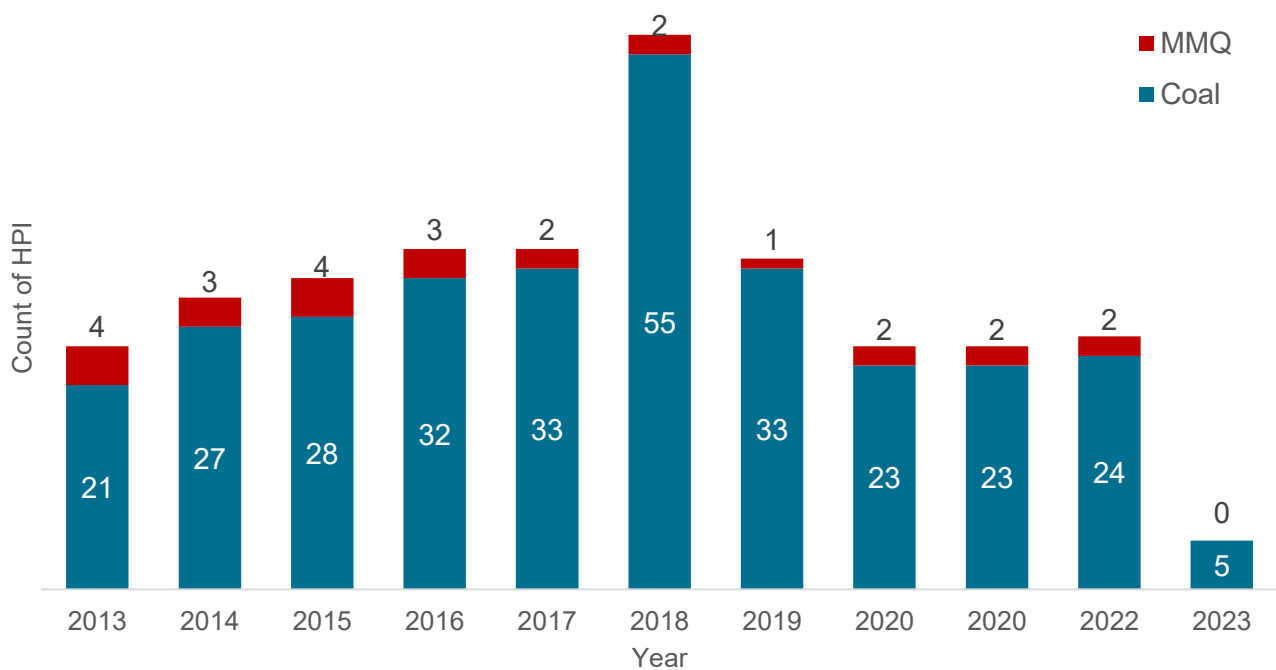


Figure 2 | Count of HPIs containing references to fatigue across the coal and mineral mines and quarries (MMQ) sectors.

Horberry, et al., (2022) undertook an extensive analysis of RSHQ’s mining incident data from 2011 to 2021. The authors identified fatigue to be a factor in approximately 2.5% (662) of all reported notifiable incidents in Queensland mines (23). Fatigue-related incidents were highest at surface coal mines and when operating vehicles, particularly heavy vehicles (**figure 3**).

It is important to emphasise that the data analysed by Horberry, et al., (2022) in **Figure 3** and that examined from the HPI database, are from the same dataset. While both datasets paint a similar picture regarding the prevalence of fatigue across the industry, the additional analysis by Horberry, et al., (2022) meant a greater number of incidents were associated with fatigue. This reinforces that view that fatigue is not always clearly identified as a contributing factor. These differences in the data also highlight the limitations in RSHQ’s historic data and reporting systems. **It is acknowledged that the**



significant ongoing enhancements to reporting, complimented by education and competence building, will alleviate much of this uncertainty in the data.

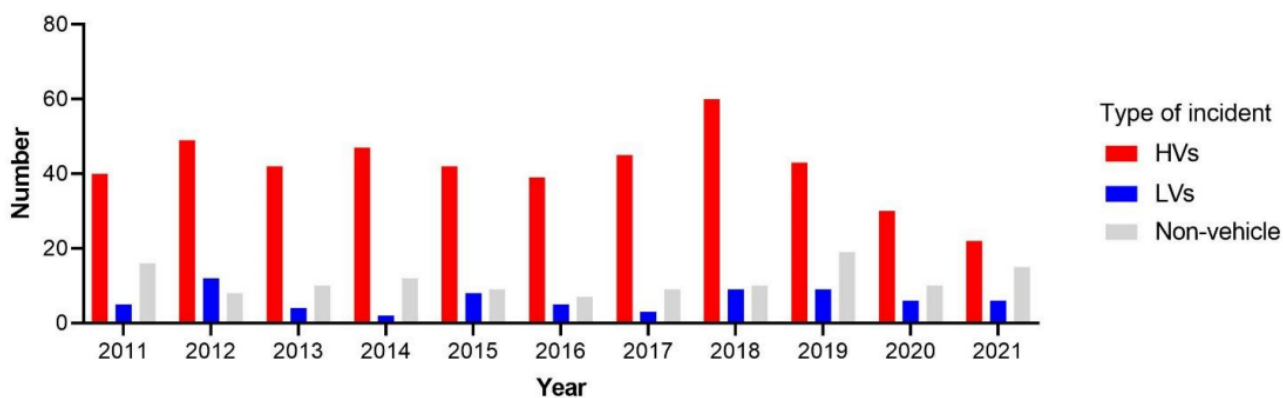


Figure 3 | Number of heavy vehicle (HV), light vehicle (LV) and non-vehicle fatigue-related incidents in Queensland mines 2011 – 2021 (23).

These figures are also likely not representing the true prevalence of fatigue across the industry. Incidents or near misses resulting from identified 'micro-sleep' are more certain, and work hours can often confirm fatigue in causality. However, the data is less clear on the role of fatigue in non-vehicle incidents, where error and impaired judgment attributable to fatigue may have contributed, or where physical fatigue is a potential contributor. This under-representation may result in the risks of fatigue not being fully appreciated by both industry and the regulator. For instance, there are approximately four times more reports of collisions made to RSHQ compared to microsleeps. It is possible that many of these collisions have an element of fatigue involved, but the focus would be predominantly on the 'uncontrolled movement of plant' or similar.

Inspection and audit findings have identified further insight into the prevalence of fatigue. An audit across two ancillary activity stakeholders (32 workers) conducted by the Petroleum and Gas Inspectorate in 2021 identified a large portion of workers (8; 25%) to be at risk of fatigue (**Figure 4**) (31). Further to this, 72% of workers were performing cognitively demanding tasks for long periods, 31% arrived to work fatigued, 41% had work hours that differed from rostered hours, and 59% were required to be on-call or available outside rostered hours. **This audit highlights important findings regarding the likelihood for fatigue and the need for further investigations across the broader resources industry.**

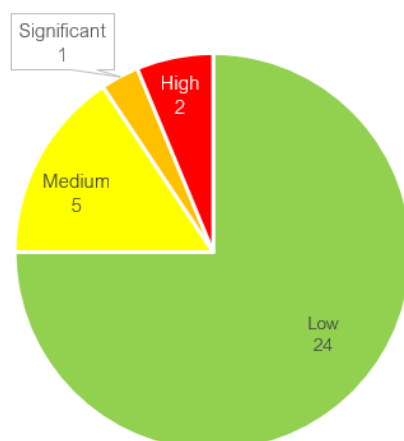


Figure 4 | Results of individual fatigue risk assessment across a cohort of 32 petroleum and gas workers (31).

3.1.2 Workers' compensation data

A brief analysis of workers' compensation cases over the previous five years has revealed a total of 23 accepted injury claims involving fatigue. As seen in **Figure 5**, the rate of claims varied across years, averaging just under five claims per year. A significant portion of the claims (40%) were attributed to vehicle accidents as the mechanism of injury. However, fatigue was only specifically called out as contributory to the agency of the injury in one of these vehicle accidents, and eight cases overall. This included a case where an open cut coal operator fell asleep driving down a ramp. This indicates a potential for under-representation and a lack of recognition or acknowledgment of fatigue as a contributing factor in the aetiology of workers' compensation claims and injuries on site.

This data also includes workers' compensation claims relating to commuting, with one claim from the 23 relating to a dump truck operator who was involved in a fatal multi-vehicle accident while travelling home from work.

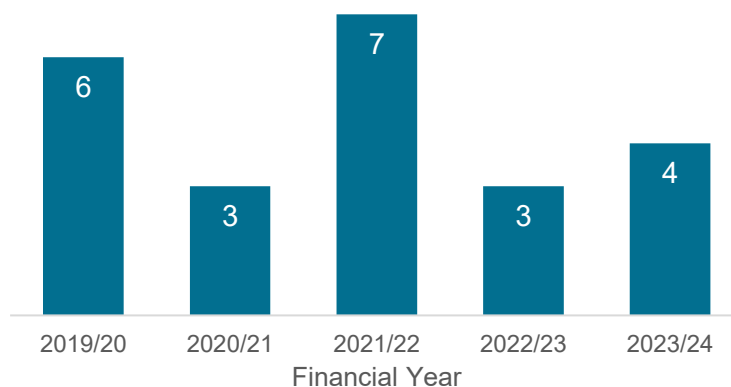


Figure 5 | Count of accepted workers' compensation claims with an injury involving fatigue across the Queensland mining industry between 1 July 2019 and 30 April 2024.

3.1.3 Safety notices

Several RSHQ safety notices have been released over recent years that link to worker fatigue. Many of these are general in nature, referencing an 'increase in reported incidents' that include fatigue.

- Safety Alert no. 211 (2023): On-highway truck and trailer rollovers at mines
- Safety Alert no. 434 (2023): Rear dump truck rollover
- Safety Alert no. 356 (2018): Vehicle roll-overs
- Safety Alert no. Newsflash (2019): Collision: Rear Dump Trucks (Nose to tail)
- Safety Alert no. 354 (2018): Persons and mobile plant falling over edges
- Safety Alert no. 163 (2017): Safety and health management system elements and guidance for effective risk management of fatigue
- Safety bulletin no. 162 (2017): Mobile equipment collisions
- Safety Alert no. 292 (2012): Rear dump truck collision and fatigue
- Safety Alert no. 285 (2012): Inappropriate use of pre-workout supplements
- Safety Alert no. 246 (2010): Driving while fatigued.

3.1.4 Enterprise operating system (EOS) – OneRSHQ Platform

A new incident reporting solution has been piloted by RSHQ in the Queensland resources industry, enabling data to be entered once via an online portal and utilised in multiple ways. This will significantly improve oversight of fatigue management by enhancing the data that informs RSHQ's future regulatory activities. The workflow for submitting an accident or incident report via the portal is illustrated below (**Figure 6**).

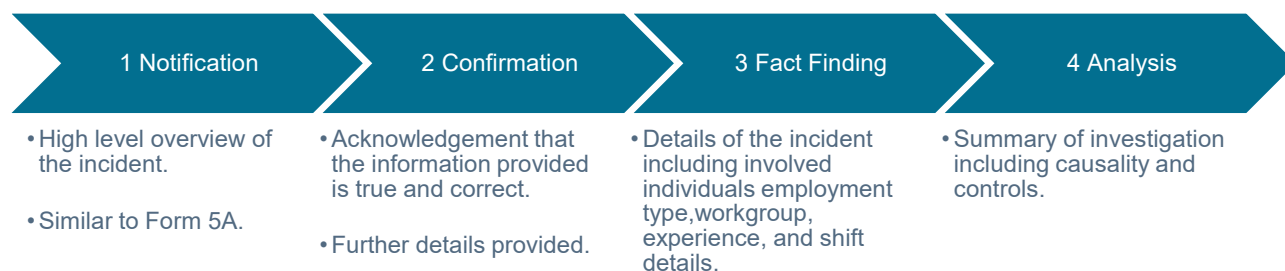


Figure 6 | Workflow for industry entries to RSHQ's new incident and accident reporting portal.

Fatigue is captured in the 'Additional details' section of the *Confirmation tab* of the incident reporting system, under psychosocial as the topic and 'microsleep' as the event (**figure 7**).

Choose one record and click Select to continue

✓	Name ↑	Topic ↑
☐	Bullying	Psychosocial
☐	Conflict or poor workplace relationships and interactions	Psychosocial
☐	Harassment excluding sexual harassment	Psychosocial
☒	Microsleep	Psychosocial
☐	Other psychosocial event	Psychosocial
☐	Sexual assault sexual harassment	Psychosocial
☐	Traumatic events	Psychosocial
☐	Violence and aggression	Psychosocial

Figure 7 | Microsleep (as a proxy for fatigue) captured in the RSHQ incident report form.

Selection of the microsleep option then enables further detail to be added from a drop-down list in the *Analysis tab* for causality (**Figure 8**). For each causal factor, another drop-down list is provided to identify the associated ineffective controls, followed by another list that indicates controls that are going to be implemented. The system also prompts updates to the site SHMS as well as communication of the changes to workers.

Choose one record and click Select to continue

✓	Name ↑	Event Item
☐	Commuting	Microsleep
☐	Environmental conditions	Microsleep
☐	Extended work hours	Microsleep
☐	Failure to recognise signs of fatigue	Microsleep
☐	Health issues	Microsleep
☐	Low level of lighting	Microsleep
☐	Medication	Microsleep
☐	Poor sleep quality	Microsleep
☐	Repetitive activity	Microsleep
☐	Roster	Microsleep
☐	Shift design	Microsleep
☐	Sleep disorder	Microsleep

Figure 8 | Causality options for the microsleep event in the RSHQ incident report form.

In ongoing efforts to enhance workplace safety and align systems with best practice, it is crucial that RSHQ's incident reporting system remains contemporary, comprehensive, and precise. Given the increasing emphasis on fatigue-related incidents within the industry, ongoing review and enhancements of the incident reporting portal will help ensure that all aspects of fatigue are accurately captured, thereby allowing better data analysis and risk management. Where fatigue is identified in the incident causality, investigations should consider shifts, overtime, awake hours, sleep achieved, medical conditions, sleep disorders, breaks, and presence of fatigue signs or symptoms. See [Section 4](#) for a discussion on factors contributing to fatigue that has relevance to causality options included in EOS.

A soft launch of the platform began in July 2023, involving 25 mine sites. Since the launch of the reporting system, 15 fatigue-related incidents have been reported (to July 2024). These are predominantly high potential incidents involving vehicle collisions where the operator has reported experiencing a microsleep. As with the HPI data explored previously, this number also likely represents an underreporting of actual incidents related to fatigue. However, the advantage of the EOS system is that most information on incidents is captured in defined data fields rather than open text. This allows a greater level of analysis and insight. For example, the time that an event occurs can be used to make inferences about the potential for fatigue to be involved. Where a site is reporting a disproportionate number of events in the early hours of the morning, regardless of whether fatigue has been identified in the causality, this would indicate a potential issue with the site's fatigue risk management.

3.2 Labour hire and contractors

The resources sector has grown to rely more heavily on contractors, labour hire agencies, and service providers in recent years (32). This poses specific challenges relating to fatigue risk management. Research has shown that on average, labour hire and contractors work longer hours compared with direct employees

across the industry, particularly in the metalliferous sector (6). These employment arrangements also often involve inconsistent scheduling and a lack of control over work conditions. This translates to a greater fatigue risk for this cohort. For example, an RSHQ inspector described the situation where shutdown crews move from site to site, often without regard to total hours worked or the type of work performed.

Analysis of the HPI reporting database has indicated a greater fatigue risk for labour hire and contractors. Site SHMSs may not adequately consider fatigue risks with contract and labour hire arrangements, particularly concerning commute distances, breaks between shifts, and accommodation provisions (33). They may also not adequately integrate with contractor safety and health management plans, resulting in specific safety and health management frameworks that do not align.

Financial arrangements such as cost-plus contracts for labour hire and contractors can also dictate the level of innovation and critical thinking applied to fatigue risk management. A cost-plus contract is an agreement where the contractor is reimbursed for all allowed expenses plus an additional payment, usually a percentage of the project costs, as profit. While a cost-plus contract reimburses expenses, some contractors may still feel pressure to keep costs down to remain competitive when bidding for future contracts. This could lead to a more superficial or reactive approach to risk management, prioritising short-term savings over a thorough, proactive approach to worker safety. As one industry representative explained, 'cost-plus contracts do not allow anything beyond meeting minimum standards for safety and health risk management'.

Contractors and labour hire were a key focus of the *Fatigue Management Forum* in Emerald (28 May 2024) arranged by the former Commissioner for Resources Safety and Health (34). Discussions at the forum centred around the lack of oversight operators have over the work patterns and hours of work of contract staff, placing this workgroup at increased risk.

4.0 Factors contributing to fatigue

The development and implementation of effective intervention strategies requires an understanding of the factors 'causing' undesired occupational health outcomes. **Causality can include work-related factors that increase the probability and/or severity of harm, as well as factors external to the workplace, or a combination of both (35) (10). Determining the causes of health outcomes is often difficult as there is not always a linear, timely relationship between exposure and the harmful event.** For health hazards such as fatigue, impacts may have a latency of years or even decades prior to manifesting (35). Causal mechanisms also differ widely, and a variety of causal models are often required to support occupational health management. Given the difficulty in assigning causality, health hazards are typically poorly documented and inadequately acknowledged (35).



Drews, et al., (2020) presented a model for fatigue, which demonstrates how factors affecting sleep contribute to impairment (**Figure 9**) (9). The authors have broadly categorised impairment to differentiate the psychological, physiological, cognitive, and behavioural impacts of fatigue. This model is also useful for highlighting factors contributing to fatigue that fall under workplace control (e.g., previous shifts), versus those that the employer has less influence over (e.g., personal life events).

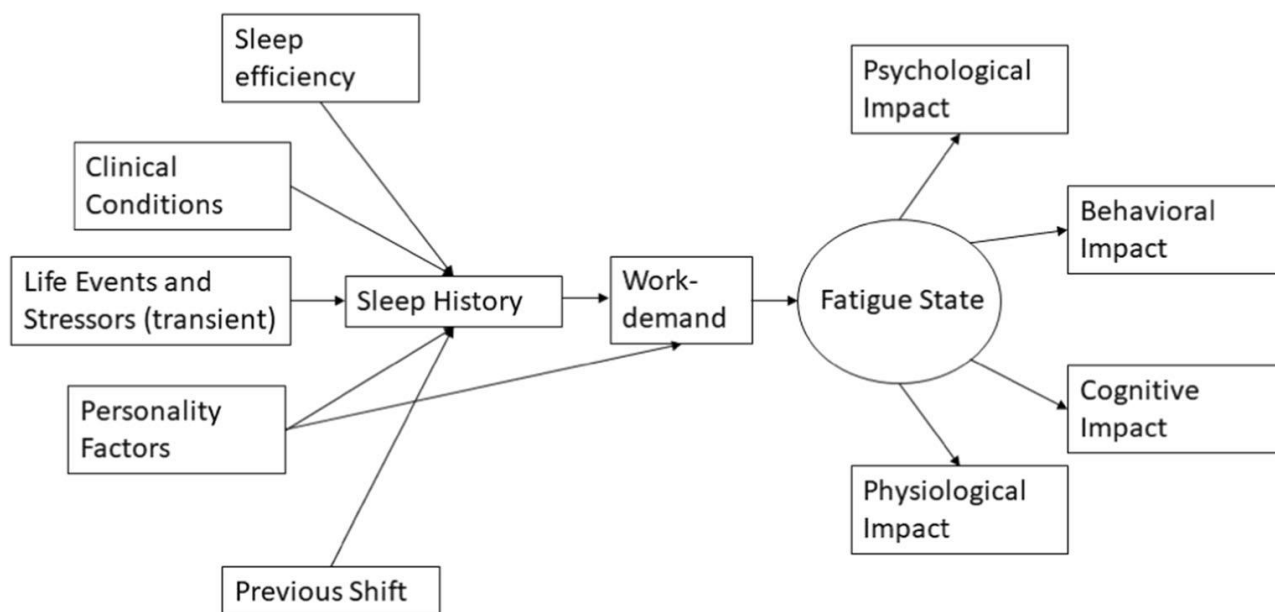


Figure 9 | Conceptual model of fatigue as designed by Drews, Rogers, Talebi, and Lee (2020) (9).

This model is effective for highlighting the global factors that may impact sleep and subsequently lead to fatigue, but in reality, fatigue is much more complex. A proposed fatigue causality diagram, which attempts to portray this complexity, has been presented in **Appendix A**.

4.1 Work design

Work design considers aspects of the work that is performed, the working environment, the physical and emotional capacities and needs of workers, and the systems and processes that govern the work (**Figure 10**) (36). This recognises the traditionally considered *work-related* contributors to fatigue risk, such as:

- Scheduling, including extended work hours and on-call duties
- Cognitive, emotional, and physical demands of the work performed
- Environmental factors, e.g., lighting, temperature, noise, etc.
- Rest environment (including adequacy and availability of accommodation facilities)
- Knowledge and awareness of fatigue risk
- Commuting times.

However, consideration for how work design factors influence fatigue risk, also requires assessment of individual and non-work factors that increase fatigue risk:

- Health issues (acute and chronic)
- Family responsibilities
- Lifestyle choices, e.g., alcohol intake
- Rest environment (if rest taken away from worksite)
- Secondary employment
- Age
- Regulatory environment the worker and employee are operating in.

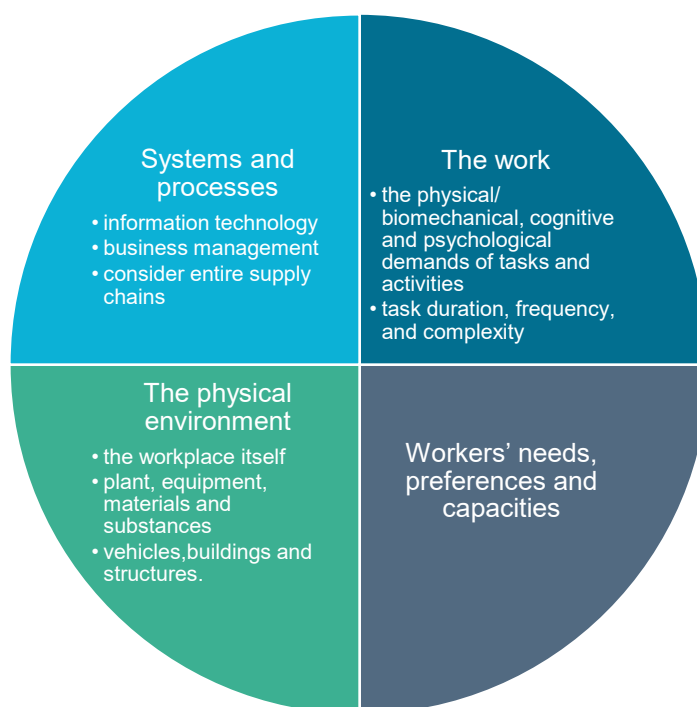


Figure 10 | Components of work design that could impact the risk of fatigue for an individual and across an organisation (36).

This systems perspective, considering good work design principles, is integral to developing a robust understanding of fatigue aetiology, and the development of subsequent controls (8).

4.2 Work scheduling

Work scheduling plays a crucial role in influencing fatigue risk, impacting both physical and mental wellbeing. Work scheduling refers to the planning and organisation of work hours and shifts for employees within an organisation. It involves determining the specific times and durations employees are expected to work, including the start and end times of shifts, break periods, and days off. Effective work scheduling aims to balance the needs of the business with the wellbeing of employees, considering factors such as workload demands, operational efficiency, and compliance with legislation.

Research consistently indicates that work arrangements which align with natural circadian rhythms are more favourable from a fatigue risk perspective (22). This means that shift work, long shift lengths, rest breaks, rostering, and shift rotation can all contribute to fatigue.

Can you adapt to night shift?

Due to the strong physiological influence of the circadian rhythm, fully adapting to night shift work (known as 'phase shifting') is very difficult. This challenge is compounded by social and domestic demands during daylight hours that limit sleep opportunity.

However, some individuals can achieve 'partial' adaptation if they are able to control light exposure and establish other protective factors such as well-timed physical activity (87).

4.2.1 Shiftwork

Shiftwork is ubiquitous across the Queensland resources industry, driven by continuous operations to maximise production. Approximately 16% of the Australian population are engaged in various forms of shift work, including rotating shifts, night shifts, and extended hours (37). Although data is limited, it can be assumed that within the Queensland resources sectors, this figure is significantly higher. Through its contribution to circadian misalignment and the impact on social and behavioural patterns, shiftwork can contribute to, and aggravate, many of the health issues associated with fatigue discussed previously (37).

Sleep deprivation and subsequent fatigue is exacerbated for shift workers, who experience sleep reductions of up to four hours per shift, particularly for early morning and night shifts. Night shift can be defined as work involving at least three hours after 11pm and before 6am (38). Shift workers face an increased susceptibility to insomnia, with prevalence estimates ranging from 26% to 45%, notably higher than the 20% prevalence observed in the broader Australian population. This impact on sleep has a direct effect on fatigue. About 32-36% of Australian shift workers reported falling asleep at work at least once a week. The risk of workplace accidents for shift workers was found to be at least 60% higher compared with those on standard work schedules (22).

Disruption to the biological drivers of sleep that shift workers experience is so pronounced that it is often referred to as 'shift work sleep disorder', characterised by impaired alertness, insomnia, and/or excessive sleepiness (22). Approximately one third (32%) of Australians who were engaged in nighttime employment experience shift work sleep disorder, with around 9% reporting severe symptoms.

4.2.2 Shift length

Several research papers have reported an approximately exponential increase in workplace accidents (as a proxy for fatigue risk) with time on shift (**Figure 11**) (19) (2) (39). A near two-fold increase in likelihood of incident or accident has been found following ten hours compared to eight hours on shift (19). A three-fold increase in accident likelihood has been found to occur after 16 hours. This is particularly true for night shift, where the longer the length of the shift, the more time is spent active and working when the body is designed to be asleep (40).

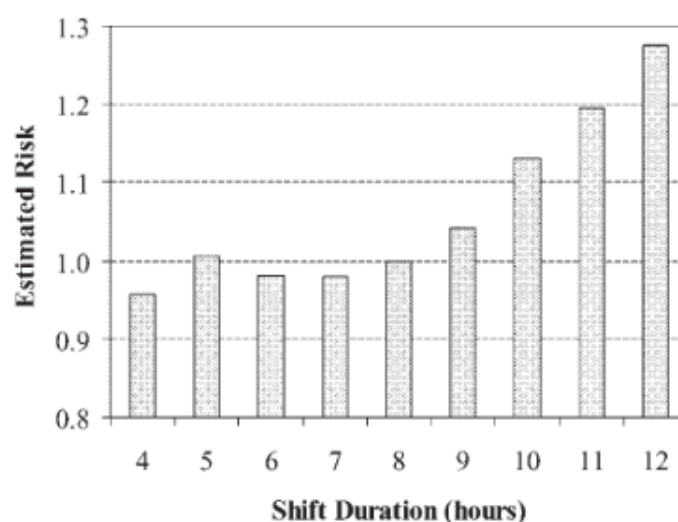


Figure 11 | The estimated relative risk across different shift lengths (39).

This is exemplified in the Queensland resource industry data analysed by Horberry, et al. (2022) who identified the highest proportion of incidents during night shift to occur during the 11th and 12th hours of the shift (**Figure 12**) (23).

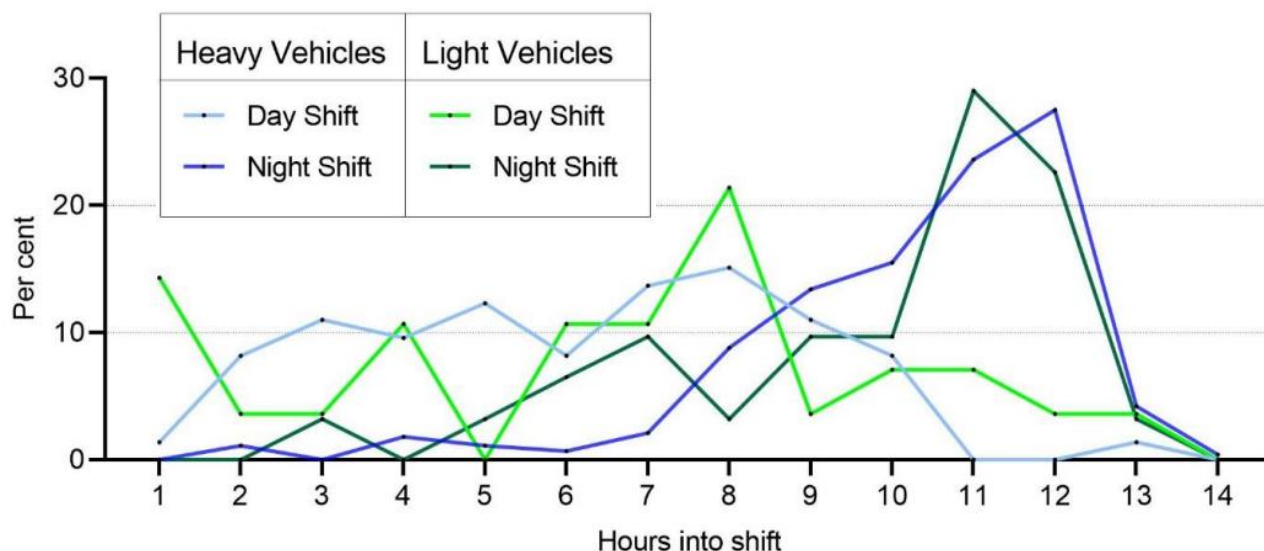


Figure 12 | Percentage of HV and LV incidents per hour into shift for day and night shift operators (2011 – 2021, n=441) (QLD) (23).

Risk is exacerbated by the quantity of sleep that the worker gets prior to starting work, with less than five hours in the 24 hours prior, and 12 hours in the 48 hours prior to starting work used as a threshold predictor of fatigue impairment (20). Studies in the rail industry have found nearly one in eight shifts (12.9%) have begun with a participant who had less than five hours sleep in the prior 24 hours, and one in four with less than 12 hours sleep in the prior 48 hours (19). This highlights the potential prevalence of fatigue-related impairment that is present at the start of the shift and has implications for fitness for work considerations for operators.

Fatigue thresholds

Given the ability to quantify risk associated with various shift durations, researchers have suggested the following thresholds for increased fatigue risk on site (19) (20):

- Working for 10 or more hours in a single shift.
- Being awake for 16 or more hours.

4.2.3 Rest breaks

Incident risk can be in-part mitigated by workers taking breaks throughout the shift (39). Tucker, Folkard and Macdonald (2003) examined the effect of rest breaks on accident risk across three years in a large engineering company (41). They found a linear increase in injury risk in the two hours of work following a break (**Figure 13**). When considered across the length of a shift, the reduction in risk observed between hour five and six has been attributed to the impacts of a break (**Figure 11**). When the authors considered the impact breaks had on estimated risk across a series of shifts, they identified a considerable difference (**Figure 14**).

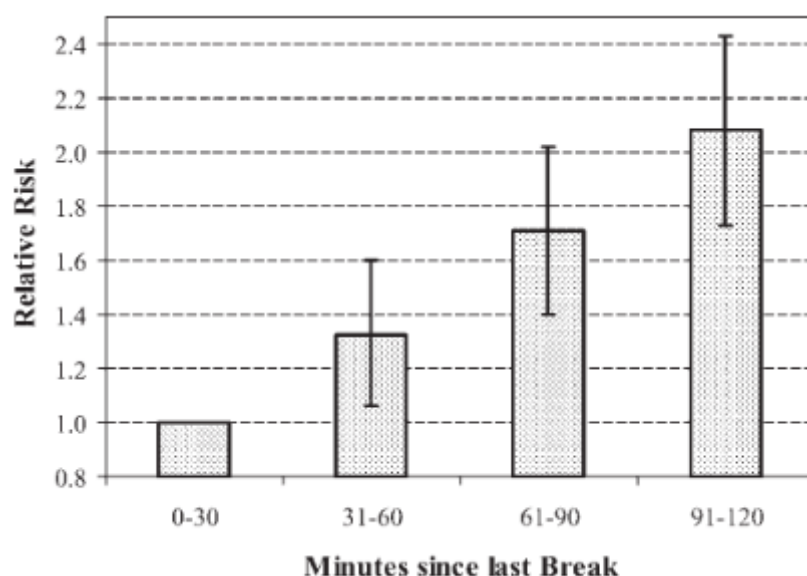


Figure 13 | The estimated relative risk across the first 2 hours of work following a break (41) (39).

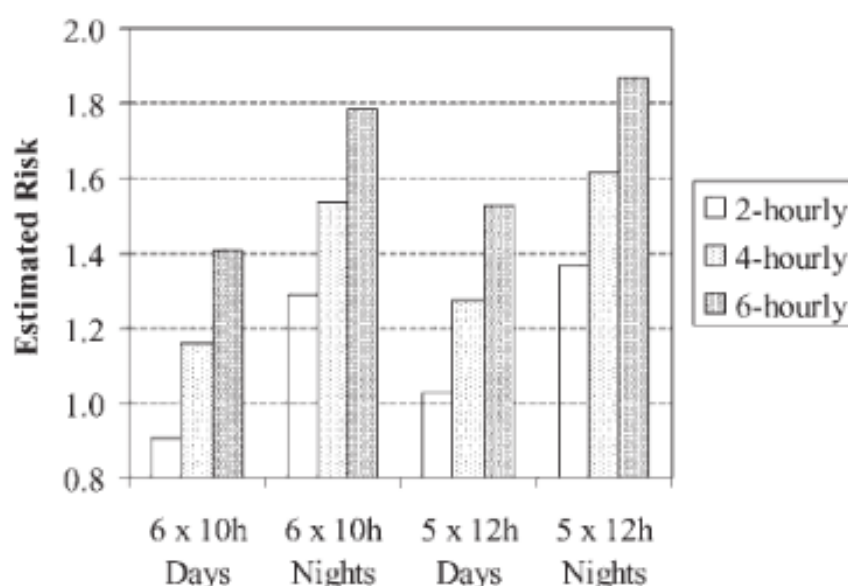


Figure 14 | The estimated risk associated with various forms of a 60 hour work week, with various intervals (2, 4 or 6 hours) between breaks (41) (39).

The length of break from the end of one shift to the start of the next can also impact fatigue risk and symptoms (42). Several studies, with large participant cohorts, have demonstrated a correlation between short breaks between shifts (i.e., less than 11 hours, known as 'quick returns') and work-related accidents, self-harm, excessive sleepiness, and absenteeism (43) (42).

4.2.4 Start times

Shift start time can also lead to circadian disruption and fatigue risk. The risk of workplace incidents increases significantly compared with day shifts, with the afternoon shift (defined as starting between 2pm and 6pm) experiencing an approximately 18% higher risk (2). This risk escalates further on the evening/night shift (starting between 6pm and 4am), where it increases to around 30%. **Figure 15** clearly demonstrates how risk increases linearly across the shift patterns.

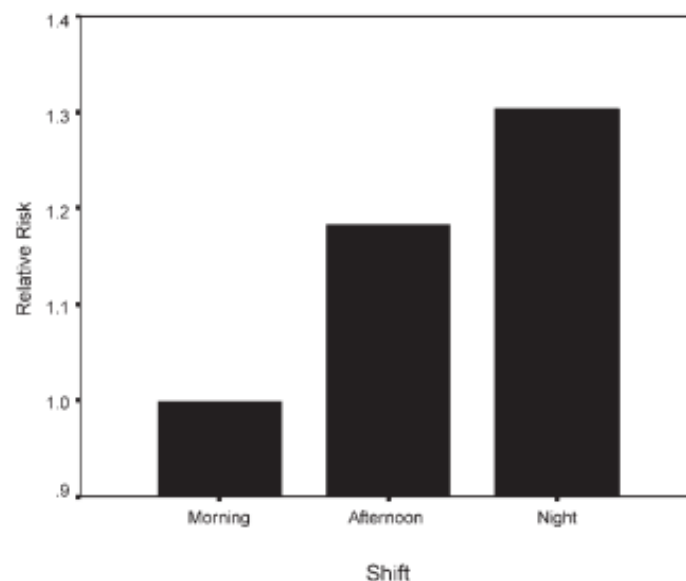


Figure 15 | Relative risk across three shift start times (44).

4.2.5 Rostering

Rostering, in the context of days of work, refers to the scheduling of employees' workdays to ensure that there is sufficient coverage to meet the organisation's operational needs while allowing for adequate rest days. This process involves determining the days employees will be required to work and the days they will have off. Rostering should be considered along with shift lengths and breaks to prevent and mitigate fatigue related impairment and negative health outcomes (44).

Broadly speaking, a longer series of shifts is associated with cumulative fatigue due to lack of restorative sleep (40). This translates to a greater relative risk as demonstrated in **Figure 16** (44). Risk was found to be 36% higher on the fourth night of night shift. A similar, smaller trend was observed across successive day shifts, with risk 17% higher by day four.

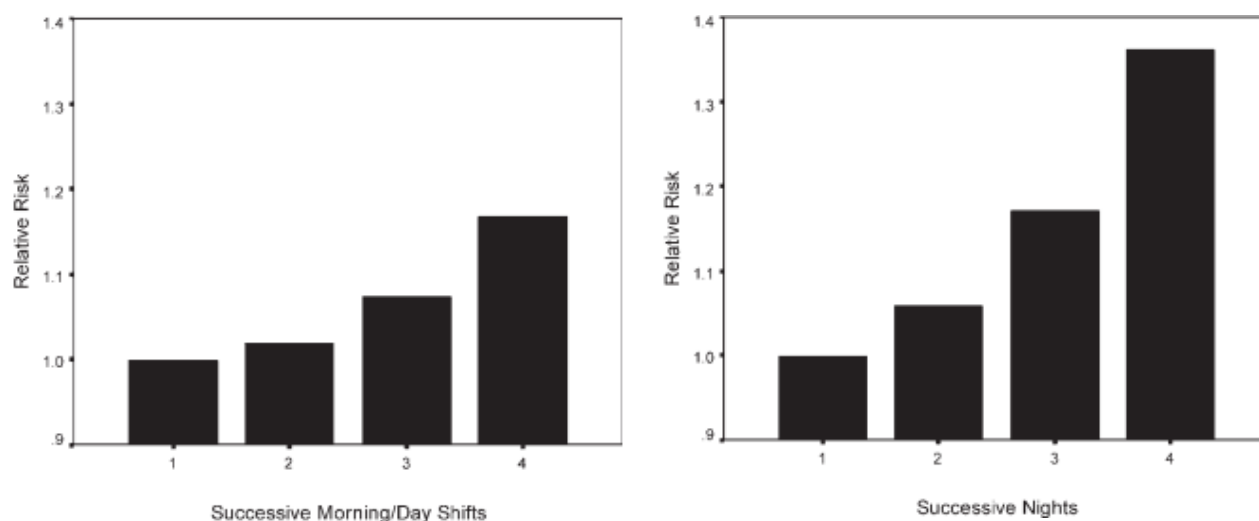


Figure 16 | Relative risk across four successive day and night shifts (44).

Although this relative risk data shows strong trends informing various shift systems, inherent limitations in safety reporting, including variability between shifts and sites, may impact the results (44).

Roster patterns have also been examined for their impact on mental health and wellbeing measures, beyond direct fatigue safety risk (4). Higher compression rosters, which have a greater number of workdays relative to days off (for example, three weeks on, one week off), allow less time for recovery and are associated with negative outcomes on mental health and wellbeing measures, including fatigue (**Figure 17**) (4). Workers following high compression rosters reported higher psychological distress scores (via the K-10 tool). This was particularly true for workers in relationships, emphasising the social impacts of these work patterns as well as the psychological (5). Workers on lower compression, even-time rosters (for example, eight days on, six days off) reported significantly better outcomes on all mental health and wellbeing measures (4).

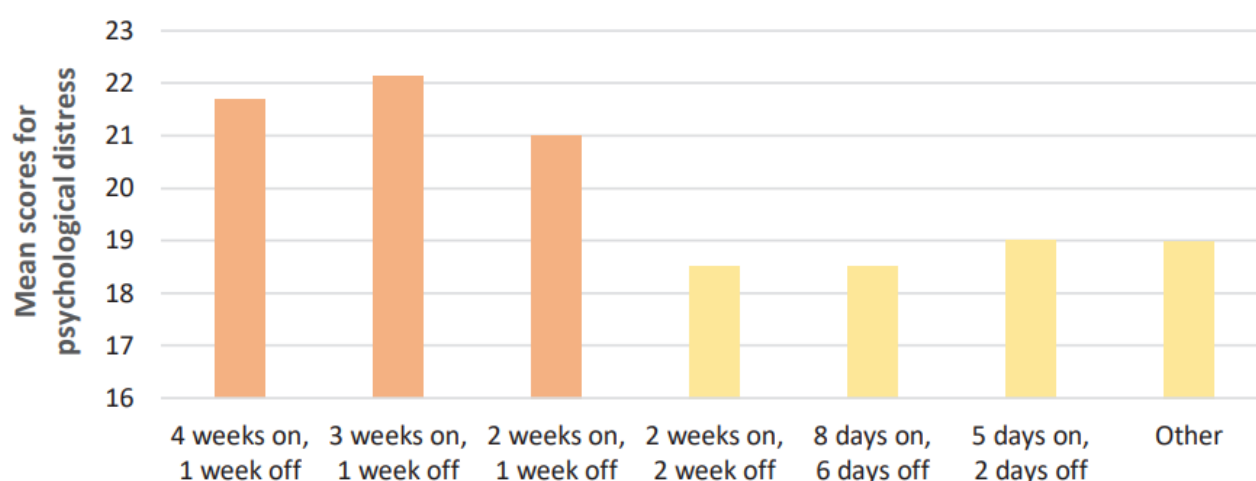


Figure 17 | Mean scores of psychological distress, including fatigue, for different rosters (4).

These findings were also identified through earlier research conducted by researchers at Edith Cohen University (2013) (5). Chronic fatigue symptoms were found in all workers, especially shift workers. Those working compressed rosters reported greater rates of psychological distress and fatigue compared with those on less compressed rotations. Concerningly, this stress was not isolated to while the worker was on shift, with stress levels increasing in the week leading up to starting shift and continuing to decline across the first few days after arriving home.

Rosters in place across the Queensland resources sector (typically with extended shift durations of 10-12 hours) include (45) (23):

- 3 days on, 1 day off, 3 nights on, 5 days off
- 4 days on, 5 days off, 5 days on, 4 days off
- 7 days on, 7 days off
- 8 days on, 6 days off
- 14 days on, 7 days off
- 14 days on, 14 days off
- 28 days on, 7 days off.

4.2.6 Shift rotation

Shift rotation refers to a work schedule system where employees alternate between different shifts within a set period. This system is commonly used in industries that require continuous operations. The rotation helps distribute the workload more evenly among employees and ensures that all shifts are adequately staffed. However, shift rotation can also disrupt circadian rhythms, impair an individual's ability to get adequate rest, and limit any adaption to a particular shift type. Following shift rotation, workers lose between one to four hours of sleep each night for approximately three nights (46). In a 2022 study of nurses, rotating shift nurses had greater perceived stress and shorter sleep duration compared with other roster patterns, including fixed-evening and fixed-night shift workers (47).

When examining shift rotation, the order of rotation should also be considered. A clockwise rotation (morning-afternoon-night) is typically tolerated better than a counterclockwise rotation (morning-night-afternoon) as it aligns more closely with the body's circadian rhythm, maximising sleep opportunity and recovery time (8) (46).

“Optimal scheduling would use a clockwise (morning-afternoon-night) rotational schedule: limiting night shifts to blocks of 3, limiting shift duration to 8 hours, and allowing 3 days of recuperation after night shifts.”
(Burgess, 2007).

4.3 Commuting

DIDO work arrangements can be a beneficial recruitment tool for organisations looking to meet large workforce requirements (5). This employment model has gained such popularity in Queensland and Western Australia that there are now more mining employees residing in large cities, like Mackay and Brisbane, and commuting to work, than living in mining towns such as Mount Isa (5). However, a DIDO work arrangement is closely linked to increased fatigue among workers.

DIDO involves long commutes to remote work sites, often requiring workers to drive several hours before and after extended shifts. This demanding travel schedule reduces the time available for rest and recovery, contributing to cumulative fatigue. Additionally, the monotonous and sometimes hazardous nature of long-distance driving can exacerbate physical and mental exhaustion. According to research, DIDO workers are more likely to be injured or killed while driving from site after a long shift, than they are at work (5). In a 2007 study of DIDO workers in the Queensland Bowen Basin, 13% of drivers reported falling asleep when driving to work, and 23% falling asleep on the drive home from night shift (48). Statistics relating to road fatalities involving Queensland resource industry workers could not be obtained due to limitations in existing data systems.

Recent road fatalities, including a fatal incident involving a 21-year-old mine worker travelling home from site, highlight the critical need for improved safety measures and support systems to protect workers both on-site and during their travel to and from work. Fatigue from DIDO arrangements not only impairs individual performance and safety but also raises broader occupational health and safety concerns within the industry, necessitating robust fatigue management strategies to mitigate risks and ensure the wellbeing of the workforce. Discussions with RSHQ inspectors suggest DIDO workers face the greatest fatigue-related safety risk as they are often operating a vehicle outside the realms of the site's SHMS.

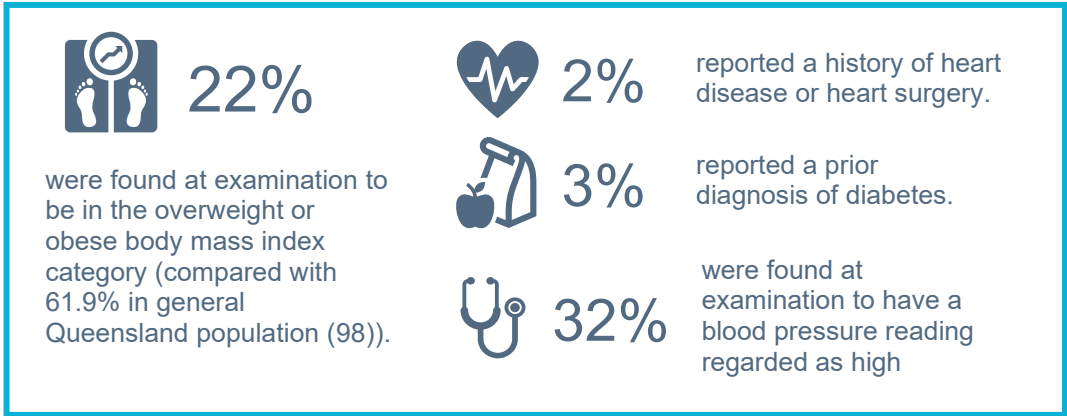
Risks associated with commuting often intersect with concerns about the adequacy and availability of accommodation facilities. Inadequate accommodation over the course of a roster can contribute to cumulative fatigue. To mitigate this, many sites offer workers access to fatigue rooms at the end of their swing. However, despite these options, both RSHQ inspectors and industry members have raised concerns that workers may still choose to drive home, potentially putting themselves and others at risk.

4.4 Health conditions

Sleep disorders have been associated with excessive daytime sleepiness and greater fatigue risk (22). Sleep disorders encompass a wide range of sleeping conditions including obstructive sleep apnoea, insomnia, shift work sleep disorder, and periodic limb movement syndrome (2). Some estimates suggest the prevalence of sleep disorders to be as high as 40% (49). These are particularly problematic when undiagnosed and untreated (22). The stigma associated with sleep disorders means many are reluctant to speak with their health care practitioner about their sleep disorder and seek treatment.

Fatigue exhibits a notable reciprocal connection with both physical and psychological health concerns. Adults facing mental health challenges such as depression and anxiety have been found to be more susceptible to sleep disturbances, and vice versa (22). Chronic physical health conditions, such as cardiovascular disease, can also exacerbate fatigue symptoms (2) (22). Research indicates that the likelihood of self-reported sleep problems increases with the number of chronic health conditions an individual has.

De-identified data from the ResHealth system for reporting of mandatory worker health assessments under the Coal Mine Workers’ Health Scheme found that for the just over 30,000 workers that completed a health assessment in the system from April 2023 to May 2024:



Given the relationship between these risk factors and the prevalence of fatigue, this data suggests that a significant portion of the workforce may be at risk – further data and analysis is required.



4.5 Lifestyle

Lifestyle factors significantly influence fatigue levels in the workplace, impacting both individual well-being and overall fatigue risk. Alcohol, caffeine, tobacco smoking, low physical activity levels, stress, and poor diet can increase the likelihood for sleep issues (22).

Alcohol is frequently used to alleviate fatigue as an aid in falling asleep, but it can have negative effects on sleep quality. It increases wakefulness and suppresses the brain's ability to engage in restorative sleep (2).

Caffeine is also frequently used by individuals to manage fatigue when adequate or restorative sleep is not available (16). Consumption of caffeine may be through coffee, energy drinks, pre-work out sports supplements, and over the counter caffeine tablets (e.g., NoDoz). These products can have between 80 to 300mg caffeine per serve. This can have an immediate positive impact on alertness and ratings of perceived sleepiness. However, inappropriate amounts and timing of caffeine can have a detrimental impact (2). Sleep problems have been found to be proportional to the quantity of caffeine consumed (22). Those over 18 years of age should consume a maximum of 400 mg caffeine per day, including a maximum of 200 mg in a single serve (50).

Similarly, illicit drug use has been anecdotally reported across mining as a way to relieve fatigue, particularly during long night shifts. Stimulants such as crystal methamphetamine ('ice') can mask tiredness, but eventually disrupt sleep patterns and reduce sleep quality. This cycle of poor sleep and ongoing exhaustion impairs cognitive function, emotional stability, and overall health. Users are reportedly getting savvy at timing their drug use to avoid workplace detection, however, simply having no traceable amount of drug in the system does not necessarily confirm the worker is fit for duty (51). In the days following use, the worker experiences a period of increased nausea, fatigue and impaired concentration as their body goes through the detox period.

Medications prescribed for certain medical conditions may also create disturbances in sleep quality or quantity, leading to subsequent fatigue (2). These include:

- some antidepressants
- selective serotonin reuptake inhibitors
- serotonin antagonists
- antipsychotic, anxiolytic, and anti-epileptic
- antihistamines
- pain medication, particularly opioids and triptans
- corticosteroids
- pseudoephedrine
- phenylpropanolamine
- theophylline.

Addressing these lifestyle factors and understanding their interplay is crucial for effectively managing workplace fatigue and promoting overall health and safety.

4.6 Cultural considerations

Cultural considerations play a significant role in understanding and managing fatigue in the workplace, as diverse cultural backgrounds can influence perceptions and practices around work, rest, and health. For instance, cultural norms may affect attitudes toward work-life balance, leading some individuals to prioritise extended work hours or view rest as a luxury rather than a necessity.

In certain cultures, communal and family responsibilities might impact the amount of personal time available for rest and recuperation, potentially contributing to fatigue. Additionally, cultural practices around diet, exercise, and stress management can influence overall energy levels and wellbeing. For example, during Ramadan, the practice of fasting from dawn until sunset can significantly impact fatigue levels, as the altered eating and sleeping patterns may disrupt normal energy levels and rest. Extended periods without food or drink, combined with late-night prayers, can contribute to increased tiredness and decreased alertness during the day. Understanding these cultural differences is essential for developing inclusive strategies that address fatigue and support the well-being of a diverse workforce.

5.0 Measuring fatigue

Given the safety and health implications, accurately measuring and quantifying fatigue and its symptoms is critical. There are various methods available to measure fatigue and fatigue impairment, including self-reporting of symptoms through questionnaires, measuring performance decline, use of wearable technologies to track sleep, behaviour monitoring, or various combinations of these (52).

5.1 Working time data

It is important that sites leverage existing data sources, such as gate entry/exit logs and electronic timekeeping systems, to accurately track hours worked by employees. This data allows for a comprehensive analysis of how planned work hours align with actual hours worked, providing critical insights into fatigue risk management at both individual and site levels. Accurate time tracking helps identify potential patterns of overwork, excessive overtime, and deviations from scheduled hours, which may contribute to fatigue-related incidents.

The integration of this data with systems used by both Human Resources and Health and Safety teams can improve the efficiency and utilisation of data collection and analysis. By sharing this information across departments, companies can create a more holistic approach to fatigue management, helping to mitigate risks while ensuring compliance with regulatory requirements.

5.2 Polysomnography

The most effective and accurate way to determine the amount and quality of sleep an individual has obtained is through polysomnography (2). Polysomnography, known as a 'sleep study', records the individual's brain waves, blood oxygen levels, heart rate, and breathing during sleep. This can measure quality and quantity of sleep, as well as supporting the diagnosis of sleep disorders that may be exacerbating fatigue levels. However, given the technical expertise required, along with the invasive testing methodology, and the financial imposition

of these systems, they are not integrated as a fatigue monitoring system, rather as a diagnostic tool to assess sleep disorders in the lab (52). Some companies have established referral pathways for sleep apnoea testing at local clinics and provided education to workers about sleep disorders to manage the risks associated with undiagnosed sleep disorders.

Given the complications associated with lab-generated sleep studies, companies such as ResMed, have developed home sleep tests, which record body movement, heart rate, and oxygenation to provide an assessment of sleep quality and potentially underlying sleep disorders. These can be useful for screening a larger pool of workers. However, some expertise is still required for interpreting results.

5.3 Actigraphy

A more accessible alternative to polysomnography is wrist-worn sleep monitors, known as actigraphy devices (2). Many smart watches and fitness bands have actigraphy capability. These devices quantify sleep movement frequency and duration to evaluate sleep quality and quantity. Actigraphy devices have been found to have accuracy rates around 82%, with accuracy growing rapidly for newer generation devices (22). However, accuracy declines rapidly for those with movement issues. Cost can also be a barrier for use.

5.4 Biomathematical modelling

Actigraphy is often used in conjunction with biomathematical modelling to provide greater accuracy to estimates of fatigue. Biomathematical modelling of fatigue uses a set of integrated equations to assess fatigue levels using metrics like recent sleep quantity, quality, sleep/wake timing, current time of day, and workload (2) (9). Calculations from biomathematical algorithms, which have been validated against performance data, accurately predict the impact of scheduling factors and subsequent fatigue on human accident risk (11). These tools pull together scientific research and knowledge regarding fatigue into generalised prediction tools (17). Biomathematical models can be useful, particularly for forward scheduling, provided the user has access to necessary expertise to understand the outputs and their limitations.

Biomathematical models can be integrated into software to rapidly analyse large datasets of sleep and work schedules to highlight fatigue hotspots and risk profiles (52). Limitations arise when the biomathematical model relies on self-reported data, as people find it difficult to estimate when they fall asleep and wake. Compared with actigraphy, sleep duration has been found to be underestimated by 30 minutes when self-reported (22). Accuracy of self-reported data is even lower for those with sleep disorders. These models do not take into consideration individual differences and all potential pre-work conditions that impact fatigue (2). As such, fatigue models generated through biomathematical modelling should not be used as the sole means of predicting fatigue risk, especially for individuals.

The Civil Aviation Safety Authority has undertaken a comparison of several biomathematical models of fatigue, considering their intended use, data required for analysis, output metrics, and sensitivity to specific fatigue factors such as time of day (**Table 2**) (17). Three of the seven models met all evaluation criteria examined.

Table 2 | Comparison of biomathematical fatigue models against a selection of evaluation criteria, completed by the Civil Aviation Safety Authority (BAM: Boeing alertness Model, CAS: Circadian Alertness Simulator, FAID: Fatigue Assessment Tool by InterDynamics, FRI: Fatigue Risk Index, SAFE: System for Aircrew Fatigue, SAFTE-FAST: Sleep, Activity, Fatigue, and Task Effectiveness model and Fatigue Avoidance Scheduling Tool, SWP: Sleep/Wake Predictor) (17).

Evaluation Criteria	BAM	CAS	FAID ¹⁸	SAFE	SAFTE-FAST	FRI	SWP
Capacity to incorporate individual-specific data	✓	✓		✓			✓
Potential for integration with Crew Scheduling Systems	✓	✓	✓	✓	✓		✓
Suitable for large scale application	✓	✓	✓	✓	✓	✓ ¹⁹	
Capacity to incorporate time zone changes	✓	✓	✓	✓	✓		✓
Capacity to consider multiple flights within a single work period	✓	✓	✓	✓	✓		
Capacity to incorporate actual sleep data	✓	✓	✓ ²⁰	✓	✓		
Capacity to consider workload	✓	✓	✓	✓	✓	✓	
Validated for use in aviation	✓	✓	✓	✓	✓	✓	✓

Key: ✓ Meets evaluation criterion

¹⁸ Most of the evaluation criteria apply to FAID TZ, specifically for personnel operating across multiple time zones. ¹⁹ It is possible to use FRI for large-scale application, but the model is cumbersome for use on large numbers of different schedules. FRI is better suited to small-scale applications. ²⁰ FAID TZ only permits the input of planned and actual in-flight augmented rest-sleep periods.

Other safety and health regulators use tools like FAID to provide objective assessment of fatigue risk, using data on hours worked and breaks taken. This information supports inspectors to have conversations with sites about effective fatigue management.

(Regulator)

5.5 Pupillography

Pupillography, a technique that measures the size and activity of the pupil in response to various stimuli, has emerged as a valuable tool for assessing fatigue (53). When an individual is fatigued, their pupillary response tends to slow down, reflecting reduced neurological responsiveness. This non-invasive method is advantageous for real-time monitoring of fatigue in various settings, such as transportation and clinical environments. The objective data obtained from pupillography can help in identifying individuals at risk of fatigue-related impairments, enabling timely interventions to enhance safety and performance.

Pupillography has been incorporated into in-vehicle monitoring of driver fatigue, for example, in the Guardian Optalert, and GuardVant systems (see [Section 8.5](#)). It is often used in conjunction with other technologies, such as operator driving behaviour monitoring, electroencephalography, and performance-based monitoring. Fatigue detection models using pupillography have been found to be accurate to 73-87% (54). Despite the potential benefits of pupillography, it should not be used as a standalone tool for fatigue management, but in

combination with other fatigue mitigation technologies, and as part of a comprehensive approach to fatigue risk management. Privacy and education are also crucial factors to consider when using these tools to ensure worker buy-in and compliance.

5.6 Self-assessment

The simplest method for assessing fatigue is using a survey or questionnaire. Questionnaires have been developed to help identify if sleepiness is a cause for concern in individual workers. Alternatively, they may screen for specific sleep disorders.

5.6.1 Individual fatigue assessments

Individual fatigue assessments utilise self-reported data relating to subjective ratings of motivation, expectation, and self-perception, rather than measuring physiological sleepiness (55). However, it is important to recognise that once an individual has become fatigued, their capacity to recognise these symptoms and their potential impairment is limited, leading them to often overlook their own fatigue as a risk. Individual fatigue assessments also often use elements of biomathematical modelling or are built into more complex modelling systems.

Examples include:

- Epworth Sleepiness Scale (ESS)
- Karolinska Sleepiness Scale (KSS)
- Fatigue Likelihood Score (FLS)
- Fatigue Severity Scale (FSS)
- Samn-Perelli Fatigue Checklist (SP).

La Trobe University (2024) examined a wide selection of tools used to detect fatigue, to determine their applicability to the occupational setting (8). The tools were mostly questionnaires developed to assess an individual's subjective assessment of fatigue, assessing items of sleepiness or drowsiness. Few used objective measures of fatigue, such as measured changes in gait, and many required further testing and refinement.

Various industries rely on these tools to inform their fatigue management approach. For example, ESS is utilised by NSW Coal Services within their statutory Order 43 medicals as well as in the National Standard for Health Assessment of Rail Workers (in addition to consideration of worker body mass index) (56) (57). Additionally, the NSW Mine Safety Advisory Council, in consultation with industry, has developed the *Fatigue management evaluation manual for the NSW mining and extractives industry* (58). A component of the evaluation process includes completion of individual fatigue assessments: the FLS and an Individual Alertness assessment. This is similar to the approach to individual fatigue assessment, undertaken by Queensland Health, and described in their *Fatigue risk management systems Implementation guideline* (59). Queensland Health includes the use of the SP as well as a fatigue likelihood calculator.

5.6.2 Sleep disorder screening

Klingman, et al. (2016) undertook a review of multiple sleep disorder screening questionnaires (49). The authors found that, although a number of single condition measures are available (such as STOP and ISI), these tools were developed for use by specialists to determine the severity of specific disorders and do not screen for multiple types of sleep disorders. To explore broader applicability of these tools, the research team undertook a review of the literature to identify instruments available that assess three or more sleep disorders.

The GSAQ was found to score highest in terms of usability and comprehensiveness. Example sleep disorder screening tools include:

- STOP (Snoring, Tired, Observed, Pressure) for sleep apnoea
- Global sleep health assessment questionnaire (GSAQ)
- Insomnia severity index (ISI)
- Obstructive Sleep Apnea-50 (OSA-50).

In the Queensland resources context, the STOP-BANG (Snoring, Tired, Observed, Pressure, BMI, Age, Neck size, Gender) tool for obstructive sleep apnoea tool is proposed to be included in a revised version of the *Guideline for the medical assessment of mines rescue personnel*. Consultation will be undertaken on the revised draft version once finalised. The STOP-BANG tool was recommended by medical experts to capture underlying sleep disorders in mines rescue personnel that may impact their suitability to safely perform mines rescue functions. It is also used in the 2024 revision of the *National Standard for Health Assessments of Rail Safety Workers* (60). As part of the health assessment for rail safety workers, an initial assessment using the ESS is administered to ascertain presence of excessive sleepiness or inattentiveness. If the ESS score is greater than 16 (out of 24), this triggers assessment using STOP-BANG and review of the workers' fitness for duty. The addition of the STOP-BANG assessment following the ESS is a new addition within the 2024 revision of the standard. The importance of assessing for undiagnosed sleep disorders was highlighted by several doctors at the RSHQ Doctor Workshop held in Brisbane in October 2024.

5.6.3 Chronotype

Individual standardised surveys can also be helpful to ascertain an individual's chronotype (17). The Morningness-Eveningness Questionnaire or the Munich Chronotype Questionnaire both consider aspects of preferred sleep-wake times, alertness throughout the day, and other sleep-related behaviours to determine chronotype. Results of these surveys, in combination with other data such as actigraphy or biological markers of circadian rhythm (melatonin and cortisol levels), provide practical insights into a worker's suitability for particular shift patterns. While it may be impractical to create customised work hour models based on each worker's chronotype, it would be reasonable to consider this when determining workgroup fatigue risk profiles and management plans.



6.0 Regulatory context

6.1 Queensland resources industry

6.1.1 Petroleum and Gas

In Queensland, health and safety in the petroleum and gas industry is governed through several pieces of legislation, including the *Petroleum and Gas (Production and Safety) Act 2004* (Qld) and the *Work Health and Safety Act 2011* (Qld). Where operations overlap, the petroleum and gas legislation also integrates with the *Coal Mining Safety and Health Act 1999* (Qld).

Fatigue is broadly addressed within the *Petroleum and Gas (Production and Safety) Act 2004* (Qld) in the context of the operator's obligations to implement and maintain a safety management system (s. 674). Section 675 of the Act outlines the mandatory elements of a safety management system for all operating plants, which would include measures to identify and manage risks like fatigue. Further, section 699 of the Act describes general obligations to keep risk to person or property to an acceptable level. Consideration of likelihood, severity, and whether the incident is avoidable should all inform the assessment of what is an acceptable level of risk (s. 700).

The executive safety manager of the operating plant (noting there may be multiple operating plants active on the tenure) must approve the safety management system in place for the plant and ensure it is effectively implemented (s. 688). If the safety management system or the RSHQ Chief Inspector requires it, the operator must also appoint one or more site safety managers to take carriage of safety management system implementation (s. 692) (**figure 18**).

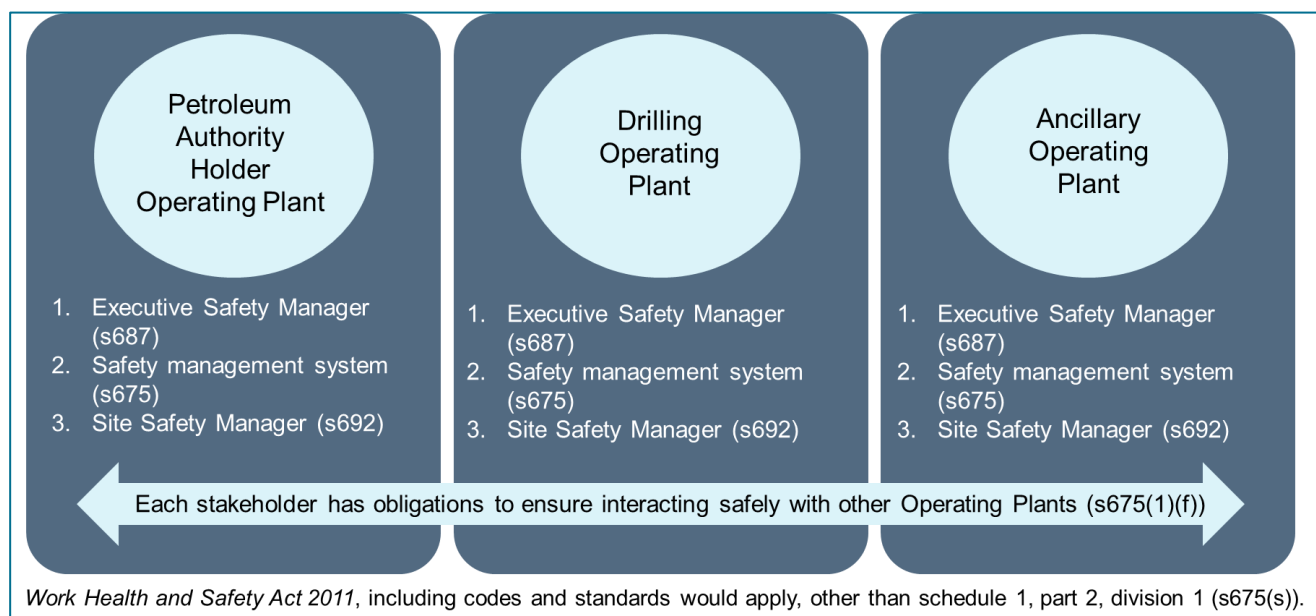


Figure 18 | Application of the *Petroleum and Gas (Production and Safety) Act 2004* (Qld) demonstrating overlapping obligations of Operating Plants for implementing effective safety management systems.

6.1.2 Coal

The *Coal Mining Safety and Health Act 1999* (Qld) (s. 29) requires the level of risk from the operation of the coal mine to be at an acceptable level:

- a. within acceptable limits; and
- b. as low as reasonably achievable.

This involves consideration of the likelihood and severity of injury or illness. Section 30 of the Act goes on to describe the specific risk management elements that would be required to achieve an acceptable level of risk of injury or illness.

Under the Coal Mining Safety and Health Regulation 2017 (Qld) (s. 6), where relevant, fatigue would also be recognised as a hazard under the site's SHMS, which requires consideration of the following elements:

- a. risk identification and assessment
- b. hazard analysis
- c. hazard management and control
- d. reporting and recording relevant safety and health information and data.

Section 42 of the Regulation specifically addresses fatigue from a fitness for work perspective alongside other physical and psychological impairment, and drugs. It prescribes that the SHMS include provisions specifically designed to control risks associated with *personal* fatigue among workers. Key measures include the implementation of education programs, employee assistance programs, and the establishment of limits on working hours, per shift and per week or roster cycle. Additionally, the system is required to specify the number and length of rest breaks within shifts to ensure adequate rest and recovery for workers. These elements have also been captured in QGN16.

When developing fitness for work provisions, including for fatigue, the SSE must consult with a cross-section of coal mine workers at the mine in developing the fitness provisions (s. 42(5)). If an assessment is required to determine a coal mine worker's fitness for work, the SSE must establish the criteria for the assessment in agreement with a majority of coal mine workers at the mine (s. 42(6A)). This element of the Regulation introduces a level of complexity for industry when considering the implementation of fatigue monitoring systems.

The coal mine worker also has specific obligations under the Act to carry out work and activities in a way that does not expose the person or someone else to an unacceptable level of risk (s. 39(2)). Additionally, they are required to participate in the risk management practices of the mine and comply with instructions given for safety and health of persons by the SSE

Individual fatigue monitoring systems and the Coal Mining Safety and Health Regulation 2017?

The use of individual fatigue monitoring systems in Queensland coal sites has been contentious due to nuances in the regulations relating to the intended purpose of the system.

Historically, the Inspectorate has taken the position that where the system is used as a risk monitoring tool to monitor unintended distraction events such as eye closure, the SSE would *not* require the agreement of workers under section 42(6A). Follow-up actions to manage the immediate risk of such an event may be agreed on by the worker and their supervisor.

Where the system is used as part of a broader assessment of a coal mine workers' fatigue, i.e., fitness for work, the workforce would need to agree on the use of the system and processes underpinning its use.

or operator (s. 39(c)(d)). This may include following procedures for self-assessing fatigue-related fitness for duty, and reporting to their supervisor if they feel they are too fatigued to perform their duties.

Industrial relations legislation

The *Black Coal Mining Industry Award 2020* (the Award) provides specific stipulations on working hours, emphasising the importance of breaks, maximum hours, and rest periods to ensure the safety and health of workers in the coal mining industry (61). Although this is outside the jurisdiction of RSHQ, it is important to understand how it overlaps with safety and health legislation and highlights the complexities of fatigue management on site. Part three of the Award describes requirements around hours of work. An employee's ordinary hours of work are 35 hours per week (or an average of 35 hours over the roster cycle) and up to ten hours per shift. The employer may determine the start and finish times of shifts up to ten ordinary hours. Rostering and scheduling of shifts greater than ten hours can be determined through consultation and agreement between the employer and the majority of workers. Employees are entitled to a 30-minute paid meal break for every five hours worked during rostered hours. If they are required to work more than one and a half hours past their rostered shift, then the employee will be entitled to a 30-minute paid meal break prior to starting this overtime, unless agreed otherwise. After every four hours of overtime the employee is entitled to an additional paid 30-minute meal break. If the overtime is incurred outside of their normal rostered shift times (for example, a 'call-out') the employee is entitled to a meal break of 30 minutes without deduction from pay after each five hours worked.

Coal Mine Workers' Health Scheme

The Queensland Coal Mine Workers' Health Scheme (CMWHS) is a regulatory framework designed to protect the safety and health of coal mine workers in Queensland (62). The CMWHS mandates regular health assessments for coal mine workers, including lung function tests and chest X-rays, to monitor and manage the risk of occupational diseases, such as pneumoconiosis. This proactive approach supports the early detection of disease and intervention, promoting better health outcomes for coal mine workers. The CMWHS is a crucial component of the broader regulatory efforts to maintain high safety and health standards in the Queensland coal mining industry.

The CMWHS captures information that has relevance to the worker's fatigue risk profile including the workers:

- Hazard exposure, e.g., potential exposure to vibration, noise, dust and fumes, and health/humidity.
- Use of personal protective equipment, e.g., noise protection.
- Medical history, e.g., heart disease or high blood pressure.
- Anthropometric measures, e.g., weight and height.
- Consideration of the impact on lifestyle factors on fitness for duty, e.g., dietary habits, exercise, stress, alcohol, and drugs.
- Consideration for other factors that may impact fitness for duty, e.g., shift work.

Despite the inferences that can be drawn from the above metrics, **there is no section of the health assessment that explicitly assesses the worker's risk of fatigue, and how this may be impacting their fitness for duty.** This differs from health surveillance conducted in other jurisdictions that include specific tools to assess how fatigue may potentially be impacting fitness for work (see [Section 5.6](#)).



The ResHealth system is an online platform developed to manage and streamline the health assessments of coal mine workers under the CMWHS. It serves as a centralised digital system that allows health professionals to securely upload and manage workers' health data, including medical assessments and records. Digitising the health assessment presents an opportunity to collect and analyse data on coal mine worker health.

6.1.3 Mineral Mines and Quarries

The *Mining and Quarrying Safety and Health Act 1999* (Qld) describes a requirement to achieve an acceptable level of risk to a person from operations (s. 26). The systematic application of risk management policies, procedures and practices (described in s. 27) mirrors that detailed in the *Coal Mining Safety and Health Act 1999* (Qld) and captured in QGN16.

The Mining and Quarrying Safety and Health Regulation 2017 (Qld) also considers fatigue from a fitness for work perspective (s. 86) as well as under the site's safety and health risk management practices and procedures (s. 6-9). The risk management process articulated in the Regulation includes:

- a) hazard identification
- b) risk analysis
- c) risk reduction, with the application of controls in line with the hierarchy of controls (although not explicitly called out as the hierarchy of controls)
- d) risk monitoring.

Similar to coal, the worker has specific obligations under the *Mining and Quarrying Safety and Health Act 1999* (Qld). A worker or other person at a mine must manage the risk of injury or illness in their own work and activities and ensure the risks are at an acceptable level within their responsibilities. They must also follow safety instructions, participate in risk management practices, work only when fit, and avoid actions that could harm others' safety and health.

The Mining and Quarrying Safety and Health Regulation 2017 (Qld) also emphasises the importance of workers periodically conducting a self-assessment of their fitness level, including consideration of fatigue (s. 86). This is in addition to the obligation on the SSE to assess worker fitness levels and maintain records of these assessments (fitness assessment record) (s. 87). The Regulation describes the requirements for this assessment, including the engagement of an appropriate doctor where necessary.

Although Schedule 2E of the Mining and Quarrying Safety and Health Regulation 2017 (s. 5) requires the SSE to arrange health surveillance for workers where exposure to a hazard could cause an adverse health effect, amendments to the Regulation (s. 145L) that commenced in 2020 introduced mandatory respiratory health surveillance for mineral mines and quarries workers. However, the mineral mines and quarries respiratory health surveillance does not capture the breadth of health measures that is reported under the CMWHS, focusing solely on respiratory health. As a result, less inferences can be drawn regarding worker fatigue risk. **Further exploration for how fatigue can integrate with the respiratory health surveillance or broader requirements around fitness for work would be of value.**



6.1.4 QGN16

QGN16 (40) provides non-statutory guidance for managing fatigue risks in the mining and quarrying industries under the *Coal Mining Safety and Health Act 1999* (Qld) and the *Mining and Quarrying Safety and Health Act 1999* (Qld). The current version of QGN16, published in 2013, superseded the *2001 Guidance Note for Management of Safety and Health Risks associated with Hours of Work Arrangements at Mining Operations* produced by the then Department of Natural Resources and Mines (63). The 2001 Guidance Note focused primarily on hours of work and work scheduling. It described the application of a risk management approach to hours worked, incorporating aspects of risk analysis, risk assessment and risk control.

QGN16 expands on these concepts, highlighting the multi-faceted nature of fatigue and the need for collaborative efforts to mitigate its risks. It emphasises a systematic approach to identifying, assessing, and controlling fatigue-related hazards to ensure safety. QGN16 details the development and implementation of a fatigue risk management plan (FRMP), which includes consultation, risk assessment, and regular monitoring and review. Since its publication, the knowledge base regarding fatigue risk management and industry best practice has grown.

Discussion with stakeholders, including RSHQ inspectors, has identified **opportunities to enhance QGN16, and align the Guidance Note with contemporary best practice:**



- QGN16 suggests a uniform approach to fatigue across the worksite, whereas contemporary thinking promotes application of a risk-based approach at the worksite and individual level. However, the core risk-based methodology outlined in QGN16 is of value and has direct links back to legislation.
- The guideline has an element of subjectivity, allowing differences in interpretation and application. This was emphasised at the Fatigue Management Forum in Emerald (28 May 2024) (particularly by union members present) and highlighted again at the Mining and Energy Union 2024 Site Safety and Health Representatives Conference (34).
- Components of QGN16 that may not be consistently applied across all sectors, for example, *Journey Management Plans* reported by one inspector to not routinely be used in Queensland quarries, particularly smaller operations.
- Journey management plans do not consider other hazards relating to commuting such as driving on rural and remote roads.
- Inspectors raised the challenges of an overly prescriptive and compliance heavy approach, while also highlighting the benefits of providing specific guidance to ensure a 'minimum standard' is applied across industry. For example, the *risk factors and control* tables provided in QGN16 to assess fatigue risk is a practical, simple tool that industry has been observed to use to inform risk and implement controls.
- Research has highlighted the preference towards application of procedural ('lower order') controls rather than practical controls for fatigue, including across industry and within QGN16 (23). QGN16 requires further emphasis on higher order controls.
- Despite the prescriptive guidance provided in QGN16 and the integration of these limits into the site's SHMS, workers reportedly frequently exceed their hour limits (23). This underscores the need to address the discrepancy between planned and actual hours in fatigue management.

Although QGN16 is non-statutory guidance, sites have used it as a reference to develop their FRMP.

A fatigue recognised standard or guideline, in lieu of QGN16?

Discussions regarding QGN16 at the 2024 Fatigue Management Forum centred around the appropriateness of a statutory recognised standard for the industry (34). It was suggested, particularly by union representatives present, that a statutory fatigue management tool would apply more pressure on operators to address their fatigue risk compared with a guidance note. In other jurisdictions, Safe Work Australia is drafting a Code of Practice for the Management of Fatigue (as opposed to their guide currently in circulation). Investigation of the implementation of a fatigue management Recognised Standard was also a recommendation of the Coroner's inquest into the deaths of Graham Brown, Malcolm Mackenzie and Robert Wilson (25).

However, it was emphasised that a recognised standard is in effect, a form of legislation, and perhaps it would be beneficial to assess the effectiveness of the legislation and existing controls in the first instance, with a focus on addressing risk to as low as reasonably achievable rather than focusing on compliance. Additionally, given the inherent differences in application of fatigue risk management across sites and industries, it would be difficult to develop a concise, practical, statutory Recognised Standard or Guideline for fatigue. Industry representatives interviewed for this review have also suggested that they are best placed to manage the site-specific risks, and that fatigue management would not be improved through the creation of statutory fatigue management material.

The 2024 release of the draft *Safe Work Australia Model Code of Practice for Managing Fatigue Risk* suggests moving towards a stronger regulatory position in broader workplace health and safety that may place greater pressure for similar approach in resources, particularly if adopted by Workplace Health and Safety Queensland.

Comparison with other material

Similar to QGN16, most fatigue-related guidance material and codes of practice reviewed from across Australia utilise an element of prescriptive measures to ascertain fatigue risk. This includes measures for assessing fatigue likelihood, such as time-on-task, recovery times, shift durations, etc. These have been captured in **Appendix B**, through a comparison of QGN16 against SWA's Guideline for managing fatigue risks in the workplace. A second table in Appendix B has been provided to outline fatigue management measures that were not explicitly mentioned in QGN16 but found in other regulatory/guidance material.

This review of fatigue material highlights the strong alignment across guidance and regulatory material. However, many caveat these resources as guidance material only, emphasising that scheduling decisions should be informed by the risk assessment process (64).

Horberry, et al. (2022) also undertook a gap analysis of QGN16 as part of their research into the effectiveness of current fatigue management processes from industry (23). To support their findings, they completed a bow-tie risk assessment using the preventative and mitigating controls described in QGN16.

The authors identified most controls in QGN16 to be preventative rather than mitigating, predominantly under the work scheduling and planning threat line. However, they expressed concern at the structure and phrasing of

many controls, referencing the 2015 International Council on Mining and Metal's framework for occupational health and safety control management, which defines a control as “an act, object (engineered) or system (combination of act and object) intended to directly (or of itself) prevent or mitigate an unwanted event”. As such, they replaced many of the controls from QGN16 in the bow-tie with controls that better align with the newer definition of a control.

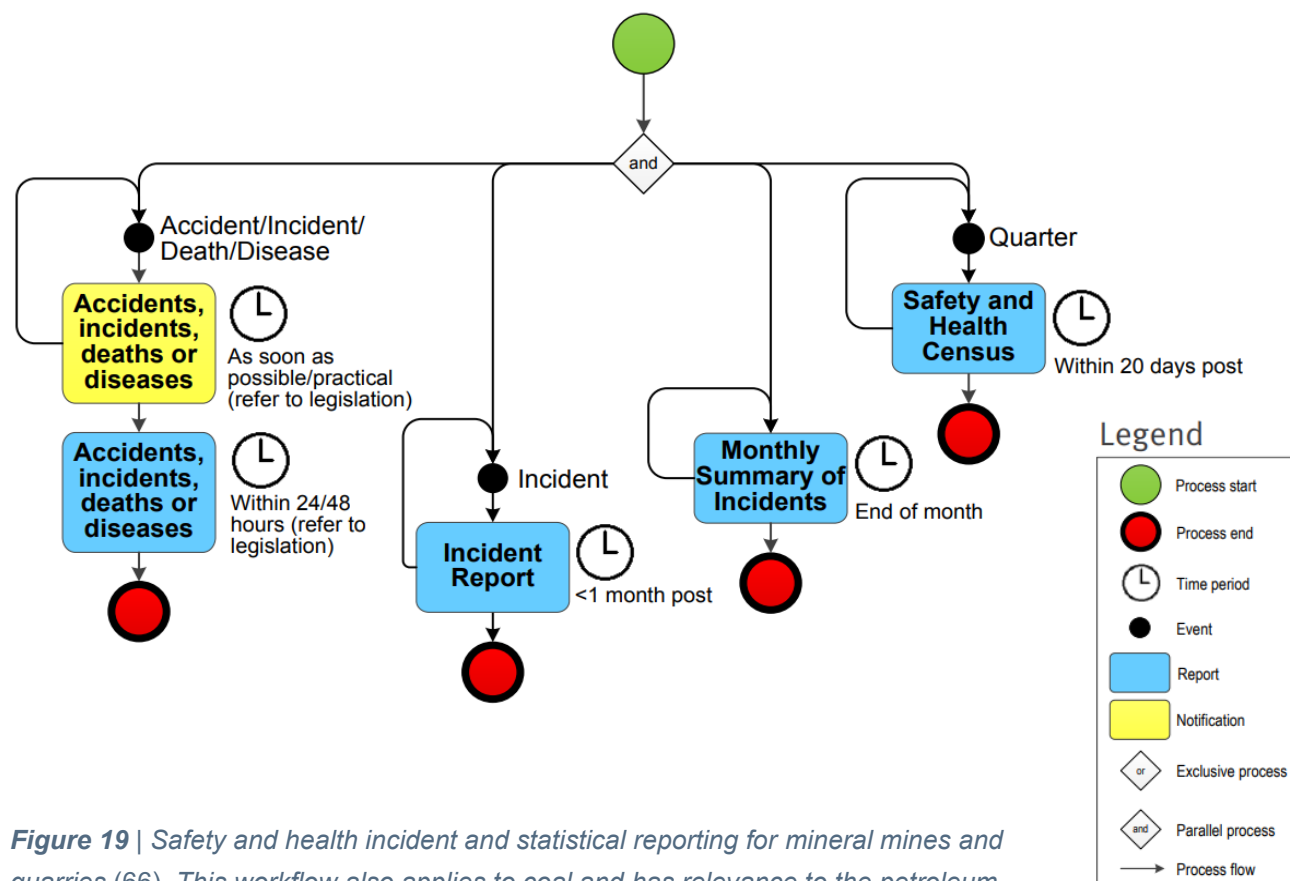
6.1.5 Mining Hazard Database

The Chief Executive Officer “Mining Hazards Database”, previously required to be provided under s. 280 of the *Coal Mining Safety and Health Act 1999* (Qld) and s. 260 of the *Mining and Quarrying Safety and Health Act 1999* (Qld) includes fatigue as a general hazard relevant across mining operations (65). This emphasises fatigue’s relevance as a critical risk to be managed on site. The database includes several key fatigue-related risks and their mechanisms. However, it does not contain the depth of information that is conveyed in QGN16 and cannot be relied on in isolation to prompt adequate fatigue risk management. **Expansion of this database will help ensure controls provided reflect contemporary best practice.**



6.1.6 RSHQ reporting and investigations

Reporting a serious accident, high potential incident or other non-reportable incident to RSHQ involves a structured process designed to ensure timely and accurate communication. The steps may vary slightly depending on the specific industry, but the overall framework remains relatively consistent (**Figure 19**).



Several publications are available to industry to support the completion of incident reports and monthly summaries:

- Guideline for reporting prescribed incidents (petroleum and gas) (67).
- Queensland mining industry incident report manual (68).
- Safety and health incident and statistical reporting for metalliferous mines and quarries (66).
- Guidance note QGN06 Guidance to Metalliferous Mines and Quarries in Reporting Serious Accidents, High Potential Incidents and Diseases (69) (repealed).
- Guidance note QGN07 Guidance to coal mines in reporting serious accidents and high potential incidents to an inspector of mines or an industry safety and health representative (70).
- Further guidance regarding incident reporting is available on the Business Queensland website.

The Inspectorates may also receive complaints from workers regarding matters relating to safety or health resulting from operations. The Inspectorate has a responsibility to investigate these complaints. Between February 2002 and September 2024, there were 109 complaints made to the Mines Inspectorate relating to fatigue (average of five per year) (**Figure 20**). However, given the difficulties with how data is historically stored in lotus notes, this number may not be a true reflection of total complaints relating to fatigue. Additionally, the Petroleum and Gas Inspectorate use a different system, which was not able to be analysed for complaints for the purpose of the current state review. Issues raised through complaints received included insufficient breaks during shifts, issues with long travel times, and concerns regarding broader fatigue management on site.



Figure 20 | Complaints received to the Queensland Mines Inspectorate between 2002 and 2024.

Compliance action undertaken by RSHQ in response to incident reports, complaints, or site inspections or audits, is guided by RSHQ’s Compliance and Enforcement Policy (71). This policy outlines the principles and practices that underpin RSHQ’s compliance and enforcement actions, ranging from education to punitive action. The Mines Inspectorate has issued 74 mine record entries (investigations) between 2015 and 2023 relating to fatigue (average of eight per year) (**Figure 21**). Investigations may be undertaken in response to complaints received, based on sample techniques or in response to incidents that have occurred. The level of detail provided within RSHQ’s historical data on ‘fatigue’ related investigations and inspections within the petroleum and gas industries was not sufficient to provide an indication of the number completed. It was not possible to distinguish between personal fatigue and equipment fatigue (i.e., wear and tear).

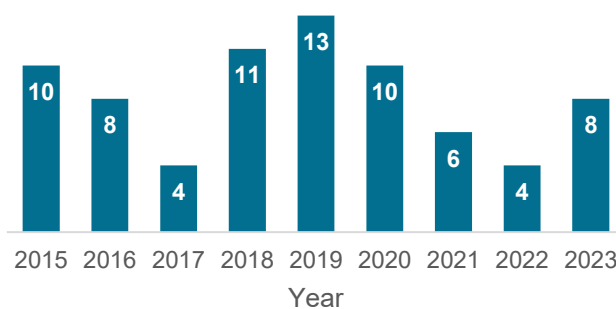


Figure 21 | Mine Record Entries (Investigations) issued by the Queensland Mines Inspectorate.

Where fatigue has been identified as a contributing or causal factor in an incident, this will be noted by site in the incident report. RSHQ investigators and/or inspectors may also undertake an investigation. The Inspectorate will examine the effectiveness of the operator's SHMS, and if an obligation failure (either deliberate or unintentional) led to the event in question. Within coal and mineral mines and quarries this investigation typically would include consideration of whether the legislative process has been followed to get agreement on rosters, etc, and how QGN16 has been applied. However, as highlighted by inspectors and discussed previously in this report, fatigue is often under-represented due to being overlooked as a causal factor. As such, many investigations would not specifically examine fatigue risk management on site. Additionally, commuting injuries or fatalities are not required to be reported via the above mechanism. The site must notify an inspector if they occur, but they will be recorded as a non-reportable injury.

The Inspectorate has released several safety notices in the past decade that relate to elements of fatigue (see [Section 4.1.3](#)). **In conversations with inspectors, it was highlighted that there were opportunities to consider proactive regulation of fatigue risk management, with RSHQ's new reporting system offering potential to inform a risk-based approach.**



Increased capability of inspectors in addressing fatigue management could support future contemporary regulation of fatigue risk management. It was noted that WorkSafe Victoria implemented a comprehensive training program focusing on psychosocial hazards, including specific elements on fatigue to enhance inspector knowledge. To complement this training, subject matter experts accompanied inspectors on-site to help them build their expertise in real-world scenarios.

6.1.7 Commuting and the legislation

As discussed in [Section 4.3](#), commuting has been recognised as a contributor to fatigue as well as a safety hazard resulting from fatigue. In Queensland, resources safety and health legislation primarily focus on worker safety at the operating plant, mine site, or quarry. As such, commuting can be interpreted to fall outside the legislative obligations of the worksite. Additionally, workers' compensation journey claims typically do not have a direct fiscal impact on employers, reducing the motivation to implement proactive commuting risk management strategies (72).

Commuting and its impact on fatigue is often considered in terms of the impact on a worker's fitness for duty, rather than the risks posed during the commute home at the end of the roster when cumulative fatigue has set in. Operators' safety and health risk management systems should account for commuting times, rest periods, and accommodation for workers traveling long distances regardless of whether they are starting or ending their

roster. The impact of commuting on worker fatigue and subsequent safety performance should be a key consideration under the broader safety and health obligations of the SSE and the site operator.

QGN16 makes several references to commuting, including factors like how far the worker resides from the site, work scheduling, and the use of journey management plans as a control measure. However, these considerations predominantly relate to the journey to site before starting a shift and the impact this has on the worker's opportunity for sleep. Journey management plans are also notoriously poorly implemented, maintained and monitored, rendering them ineffective (73). **Further clarity may be beneficial regarding the legislative requirements and jurisdictional boundaries relating to commuting, especially the journey home after a series of shifts, to further safeguard worker safety.**



As described previously, a worker also has specific obligations under the legislation, to ensure their own safety and the safety of others. At a broad level, this includes managing personal fatigue as it relates to commuting to and from site and notifying their supervisor if affected by fatigue. Consultation with RSHQ inspectors and industry has revealed an industry culture where workers regularly opt to drive home at the end of the swing, despite the operator's SHMS including provisions for them to sleep. For example, some sites stipulate a minimum four-hour sleep opportunity for their workers before commuting after a night shift. Where worker compliance with these rules is an issue, multiple RSHQ inspectors have expressed value in operators taking firmer action on workers, even considering termination in accordance with appropriate disciplinary procedures, given the worker is consciously placing themselves and others at risk. Conversely, workers also report that accommodation is not always available for pre-commute travel after a night shift.

Environmental impact assessment

Complex projects with potential for significant environmental effects and strategic significance to the region are considered by the Coordinator-General under the *State Development and Public Works Organisation Act 1971* (Qld) (74). Proponents are required to undertake and complete an environmental impact assessment (EIA) or impact assessment report (IAR) for the project. The EIA may include a social impact assessment, which considers factors around workforce management, housing and accommodation, health, and wellbeing. The 2015 inquiry into long distance commuting work practices in regional Queensland explored how EIAs address workforce factors, such as percentage workforce FIFO, for significant mining projects in the Central Queensland region (45). Caval Ridge mine for example, was originally 70% FIFO. However, an application to change the operational workforce up to 100% FIFO was made in 2011. The Coordinator-General considered and approved this proposal, justifying the change by highlighting the increased effectiveness of roster systems and improved road safety through reduced road travel. Similar changes have been accepted for other mines in the region.

6.2 Other jurisdictions

Consistent across jurisdictions is the recognition of fatigue as a hazard and the shared responsibility between workers and operators to manage fatigue. **Table 3** lists key fatigue-related regulatory and guidance material from across multiple jurisdictions in Australia. **Appendix C** provides a detailed breakdown for where fatigue is captured within some of these legislative tools (23). These materials collectively provide a robust framework for managing fatigue in various work settings, ensuring compliance with legal requirements, and promoting worker safety and health.

Table 3 | Key fatigue-related regulatory and guidance resources available by industry in Australia

Industry	Resource
Work health and safety	<ul style="list-style-type: none"> Model work health and safety legislation. Work health and safety legislation (Qld) SWA Model Code of Practice: How to manage work health and safety risks SWA: Guide for Managing the Risk of Fatigue at Work WHSQ: Preventing and managing fatigue-related risk in the workplace 2020 WHSQ: Managing the risk of psychosocial hazards at work Code of Practice 2022
Mining (non-Queensland)	<ul style="list-style-type: none"> NSW Mine Safety Advisory Council: Fatigue Management Plan 2009 WA Department of Energy, Mines, Industry Regulation and Safety: Code of Practice Working Hours WA Department of Energy, Mines, Industry Regulation and Safety: Code of Practice Fatigue Management for Commercial Vehicle Drivers 2019
Heavy vehicle transport	<ul style="list-style-type: none"> Heavy Vehicle National Law Act 2012 (Qld) and Heavy Vehicle National Law Regulation 2014 (Qld) NHVR Regulatory Advice: Fitness to drive: Fatigue
Rail	<ul style="list-style-type: none"> Rail Safety National Law (Queensland) Act 2017 and the Rail Safety National Law National Regulations 2012 Office of the National Rail Safety Regulator Fatigue Risk Management Guideline
Aviation	<ul style="list-style-type: none"> CASA: Fatigue management for the Australian aviation industry CASA: Plain English guide for fatigue management rules
Emergency services	<ul style="list-style-type: none"> SafeWork SA: Emergency Services Guideline for Risk Managing Fatigue

6.2.1 Work health and safety

Under the *Work Health and Safety Act 2011* (Qld), a Person Conducting a Business or Undertaking (PCBU) has a duty to ensure, as far as reasonably practicable, that workers and other persons are not exposed to health and safety risks arising from the business or undertaking (s. 19). A critical component of this duty is the management of fatigue, which includes providing and maintaining a safe work environment, implementing safe systems of work, and establishing mechanisms for monitoring the health of workers and workplace conditions. This duty is not negated by a worker's willingness to work particular shift patterns or additional hours (10).

Officers, such as company directors, must ensure that the PCBU complies with work health and safety duties, including allocating adequate resources and establishing processes to effectively manage fatigue-related risks (s. 27). This is similar to the overarching principles of risk management that apply in the resources sector.

Additionally, workers are required to take reasonable care for their own health and safety, ensuring that their actions do not adversely affect others and that they comply with reasonable instructions and workplace policies or procedures designed to manage fatigue (s. 28). The PCBU must consult, as far as reasonably practicable, with workers on health and safety matters that impact them, including fatigue management (s. 47). This involves sharing information and providing opportunities for workers to express their views on managing fatigue through measures such as planning and designing shift rosters, fatigue training, and incident investigation. Consultation also extends to other duty holders, such as contractors and labour hire companies, ensuring a comprehensive approach to fatigue management across the entire workforce.

Psychosocial Code of Practice

Queensland's 2022 Code of Practice for Managing the risk of psychosocial hazards at work (the Code) has provided a renewed motivation to explore the impact of fatigue on workers, beyond a traditional safety perspective. The Code provides comprehensive guidelines for identifying, assessing, and controlling psychosocial risks in the workplace to ensure the health, safety, and well-being of employees. Although fatigue is not included as one of the core 14 psychosocial hazards addressed in the code, it is captured as an underlying theme through several of the hazards. Challenging work hours or shiftwork and their link to fatigue is explicitly identified under high and/or low job demands. Fatigue is also acknowledged to exacerbate many psychosocial hazards, for example, poor workplace relationships. The release of the Code has broadened the conversation about fatigue at worksites, shifting the focus from just physical safety to a more holistic understanding of fatigue as a hazard that impacts mental health, cognitive function, and overall wellbeing.

Managing fatigue risks at work draft Code of Practice

In August 2024, Safe Work Australia released a preliminary draft of their new Code of Practice for managing fatigue risks for consideration by Australian safety and health regulators. Up to now, Safe Work Australia has only had a guide, which is reflected in the approach taken by Workplace Health and Safety Queensland and WorkSafe Victoria (10). The draft Code of Practice emphasises the risk management approach to inform the application of prescriptive hours of work controls. This has a stronger link back to legislation and aligns more closely with broader risk management principles and SHMSs.

Western Australia already has a Code of Practice, but it specifically relates to Working Hours rather than fatigue more broadly (75).

The release of a fatigue Code of Practice will help to raise the profile of the hazard, in a comparable way to what has been achieved with psychosocial hazards. It would offer greater enforceability than a guideline and ensure greater consistency in fatigue management practices across industries.

6.2.2 National Heavy Vehicle Regulator (NHVR)

Given the significant contribution of fatigue to road fatalities, the heavy vehicle industry has needed robust fatigue management practices, underpinned by strong legislation. This includes a fatigue management

accreditation program that places accountability on heavy vehicle operators (employers) to ensure the safety and wellbeing of drivers and other road users – The National Heavy Vehicle Accreditation Scheme (76). To achieve and maintain accreditation, operators must have a fatigue management system in place, with documented evidence of its effectiveness, including driver compliance.

Seven fatigue management standards are required to be met for accreditation:

1. scheduling and rostering
2. health and wellbeing for performed duty
3. training and education – including a requirement for drivers and those conducting scheduling to complete an approved training course in fatigue management delivered by approved registered training organisations
4. responsibilities and management practices
5. internal review
6. records and documentation
7. workplace conditions.

Driver scheduling and work hours are calculated and maintained under a fatigue management system. The operator has the option of applying for Advanced Fatigue Management accreditation under the Scheme. This approach requires greater consideration of the identification, assessment and effective management of fatigue risks posed by their operation. However, it allows application of a performance-based risk management approach, where operators propose their own work and rest hours rather than using the prescribed hours stated in the Heavy Vehicle National Law (76).

In addition to the accreditation Scheme, the Heavy Vehicle National Law also includes obligations relating to the Chain of Responsibility. The Chain of Responsibility duties are designed to ensure that all parties involved in the road transport supply chain, not just drivers, are held accountable for their role in ensuring safety and compliance with road transport laws. These laws aim to improve road safety and reduce heavy vehicle-related accidents by addressing factors such as fatigue, among other risks.

Changes in approach to regulating fatigue

To better support the heavy vehicle industry to manage fatigue risks, the NHVR are moving towards a risk-based approach, where operators are required to contextualise their SHMS to fatigue, rather than simply applying limitations on work and rest hours. This recognises the complexity behind fatigue aetiology, beyond simply focusing on work patterns.

To achieve such a change in regulatory approach, the NHVR have established a safety assurance team to review operator SHMSs. The NHVR are undertaking an extensive internal capability uplift with their compliance officers to provide consistency and rigor around their evaluation of operator SHMSs to ensure they are effectively managing fatigue risks.

In addition to considerable changes internally, conversations with policy staff from the NHVR office also emphasised the need to take an educative approach to compliance across industry in the first instance. There are a range of maturity levels among heavy vehicle operators when it comes to the development and implementation of their SHMS, and it is important to support smaller operators or those who may lack the resources or expertise to develop comprehensive SHMSs. By taking an educative approach, the NHVR aims to

build industry capability and foster a culture of continuous improvement. This approach will involve enforcement where required but focuses on providing guidance and support to operators in understanding and complying with fatigue management requirements.

6.2.3 Civil Aviation Safety Authority (CASA)

CASA is the government body responsible for the regulation of civil aviation in Australia against the Civil Aviation Safety Regulations 1998. New fatigue management rules (Civil Aviation Order (CAO) 48.1 Instrument 2019) came into effect in July 2021. Unlike other jurisdictions, to comply with the requirements around fatigue in the CAO 48.1, operators have the choice of using a prescriptive (prescribed limits) or flexible (performance/risk-based) approach (77). The CAO provides seven appendices which describe flight and duty time limitations either with or without the need for risk management processes or training. The CASA Fatigue Management Plain English Guide simplifies the obligations under the CAO 48.1 (78).

If an operator elects to take a performance-based approach (under appendix seven of the CAO 48.1), they will be required to establish an evidence-based FRMP, including personnel flight and duty limits, utilising SHMS and principles. The FRMP must be approved by CASA prior to operations commencing (78).

6.2.4 Office of the National Rail Safety Regulator (ONRSR)

The *Rail Safety National Law (Queensland) Act 2017* (RSNL) and the Rail Safety National Law National Regulations 2012 (National Regulations) lay down specific requirements for both rail transport operators and rail safety workers concerning the management of fatigue risks. Under these obligations, accredited rail transport operators are obligated to establish and execute a FRMP as part of their SHMS (s. 92 of the RSNL). This plan must adhere to the standards outlined in s. 29 of the National Regulations, which outlines the primary fatigue-related risk factors that operators must consider when formulating their fatigue system. These considerations include:

- hours of work, e.g., scheduling of work and non-work periods
- impact of work scheduling on social and psychological factors that may impact on performance and safety
- psychological factors arising out of work practices affecting rail safety workers, e.g., commuting time, circadian effects and chronic sleep loss effects
- the kinds of rail safety work being carried out, e.g., high physical exertion or cognitive demand
- regularity of hours and consideration of fatigue risk arising from one-off or occasional circumstances.
- suitability of rest environments
- the physical environment where work is to be carried out, including vibration and climatic conditions
- research related to fatigue and technology for managing fatigue.

Note that under s. 7 of the RSNL, the RSNL applies to a mining railway. However, to the extent that a mining railway could be regulated under both the RSNL and the *Coal Mining Safety and Health Act 1999* (Qld) or the *Mining and Quarrying Safety and Health Act 1999* (Qld), the RSNL applies to the exclusion of the relevant mining safety legislation.

6.2.5 United States of America

Fatigue management across North America is influenced by a combination of federal and state-based legislation, as well as industry-specific guidelines. The American *Fair Labor Standards Act 1938* defines employee work hours; however, it does not directly address fatigue management (2).

The Mine Safety and Health Administration (MSHA) is a key agency in the United States responsible for ensuring safe and healthy working conditions for mining employees. MSHA carries out the provisions of the *Federal Mine Safety and Health Act of 1977* as amended by the *Mine Improvement and New Emergency Response Act of 2006*. MSHA doesn't have specific regulations dedicated to fatigue management. However, MSHA does recognise fatigue as a contributing factor to mine safety incidents and addresses it indirectly through broader safety regulations and guidelines.

6.2.6 Health and Safety Executive, United Kingdom

Britain's national regulator for workplace health and safety is the Health and Safety Executive (HSE). HSE provides detailed guidance on managing fatigue risks in various sectors. This includes advice on work scheduling, shift patterns, and control measures.

In the United Kingdom (UK), fatigue is regulated primarily under the *Health and Safety at Work Act 1974* and supported by specific regulations and guidance (79). Under this Act, employers are required to ensure the health, safety, and welfare of their employees at work, which would include managing risks associated with fatigue. Employers must assess the risks of fatigue in the workplace and take measures to control it. This is similar to the approach required in the UK mining industry, which is regulated through the HSE's *Mines Regulations 2014*. Fatigue is indirectly addressed within these regulations as part of the broader duty to ensure health and safety at mining operations. While the regulations do not explicitly use the term "fatigue," they include general obligations related to managing health and safety risks, which would encompass fatigue management.

The *Working Time Regulations (1998)* and the *Working Time Directive (2003)* mandates the minimum legislative requirements for managing work scheduling (79). The Directive prescribes a minimum 11-hour rest break every 24-hour period, and at least one day off each week (2). Exemptions to this apply to those employed in armed forces, emergency, police and those employed as domestic servants in private households.

Employers must also comply with the general duties within the Management of Health and Safety at Work Regulations 1999 (79). These require employers to carry out risk assessments and implement measures to control identified risks, including those related to fatigue. Employers must consider fatigue as part of their overall risk management.

7.0 Management of fatigue risk

As discussed previously, there are many factors that influence the amount of sleep an individual needs and can achieve. When these factors are not adequately addressed, individuals can experience fatigue, which heightens risks to safety and health. Application of sleep optimisation and fatigue management strategies is essential in preventing and mitigating fatigue and promoting overall worker wellbeing. These fatigue management strategies should be captured in the SHMS for each site, including through the use of systems thinking and a FRMP.

7.1 Systems approach

Fatigue should be considered a joint responsibility between leadership and workers, and controls should not only focus on worker ‘self-management’ but be applied based on a broader conceptualisation of fatigue from a systems perspective (8). A systems perspective recognises the complexity of interrelated factors that contribute to fatigue risk, emphasising the need for holistic solutions. By considering the entire work system—such as work schedules, environmental conditions, organisational culture, and individual health—this approach aims to identify and address root causes rather than isolated symptoms.

The application of good work design principles complements this by ensuring that work tasks, environments, interactions, and schedules are structured to minimise fatigue risk. This includes designing work to allow for adequate rest, promoting work-life balance, and ensuring that job demands match worker capabilities. Together, these strategies foster a safer and more sustainable work environment that proactively addresses fatigue risks.

A systems approach also requires the evolution in thinking from a prescriptive, compliance-based approach to a dynamic, risk-based system in which the outcome is prioritised, underpinned by a framework that emphasises the shared responsibility of the worker and the operator (8). Research has shown a trend towards the risk-based



approach to fatigue management, away from prescriptive hours of service – the foundation of the FRMP (80).

In practice, application of a systems approach across industry is still on a spectrum between these two approaches, including the application of a hybrid model where elements of the FRMP are implemented alongside prescriptive rules to working hours and breaks. There are advantages and disadvantages of each of the various approaches (**Table 3**). This also allows flexibility for smaller operators who may not have the maturity in their safety management systems to allow full implementation of a risk-based FRMP.

Table 3 | Strengths and weaknesses of various fatigue management systems (80) (8) (81).

Approach	Strengths	Weaknesses
Prescriptive	<ul style="list-style-type: none">• Able to easily demonstrate compliance• Ease of implementation• Ease of management.	<ul style="list-style-type: none">• Inflexible – one size does not fit all• Can prioritise compliance over risk management• Fatigue can still be present, even when prescriptive hours are not breached• If limits are prescribed in legislation, they may be viewed as the responsibility of

Approach	Strengths	Weaknesses
		the regulator rather than individual companies <ul style="list-style-type: none"> Doesn't allow for advances in technology or alternate ways in which risk may be managed to the same level, or better.
Hybrid	<ul style="list-style-type: none"> Relatively simple to implement Can be easier to regulate than risk-based approach Offers greater flexibility than a prescriptive approach. 	<ul style="list-style-type: none"> Organisations may continue to rely on prescriptive approaches Limited risk assessment undertaken Increased burden of demonstrating compliance.
Risk-based approach	<ul style="list-style-type: none"> Tailoring of system to suit organisational context Addresses site-specific contributors to fatigue and developed tailored controls for management of risk Can accommodate technical innovation more quickly Emphasises the objective of the legislation Industry has freedom to determine the <i>means</i>, while RSHQ determines if risk has been managed to an acceptable level. 	<ul style="list-style-type: none"> Can be complex Commitment from leaders and managers This model may not work where business' interests and regulators' interests aren't aligned (e.g. production vs safety).

7.2 Fatigue risk management plan

Fatigue risk management is a critical component of ensuring the safety and wellbeing of workers, particularly in high-risk industries such as mining and petroleum and gas, where extended hours, shift work, and demanding tasks are prevalent (81). Managing the risks from fatigue in the workplace can be a complex and challenging task. A comprehensive FRMP serves as an effective framework to identifying, assessing, and controlling fatigue-related risks in the workplace. Sites should allocate sufficient time and resources for conducting fatigue risk assessments and reviews, ensuring that the assessment process includes representation from operational areas most vulnerable to fatigue-related incidents. Anecdotal evidence and reviews from other states have indicated this is not occurring.

The FRMP is a data-driven set of management practices for identifying and managing fatigue-related safety risks (80). It focuses on specific measures and procedures to manage and mitigate fatigue-related risks within an organisation. The FRMP is intended to integrate with the broader SHMS on site, enhancing the overall effectiveness of safety protocols.

By aligning with existing safety procedures, the FRMP enables a cohesive approach to risk management, reinforcing safety culture, implementation of best practices and compliance with regulatory requirements. This integration helps to create a robust safety framework that addresses fatigue prevention from a risk perspective rather than from an ad-hoc compliance with hours of work.

The NSW Mine Safety Advisory Council recommends the incorporation of the following core components to the FRMP (82):

1. Policy commitment, including a demonstration of leadership support.
2. Consultation.
3. Role clarity.
4. Risk management (IPIECA have published a fatigue management questionnaire, which prompts consideration of fatigue contributors, controls, training, and risk reduction, and presents results visually in a series of graphs that highlight key gaps and opportunities (81)):
 - a. Hazard identification, including consideration of sleep disorder prevalence.
 - b. Risk assessment.
 - c. Control of risks.
 - d. Evaluation of effectiveness of risk control processes.
5. Documentation:
 - a. Reporting systems.
 - b. Fatigue incident investigation procedures.
6. Implementation, within SHMS.
7. Evaluation and review.

These core components integrate with the following characteristics described by IPIECA (2019) as essential for successful FRMP implementation (**Table 4**) (81).

Enablers to implementation of a FRMP (80):

- A just organisational culture that facilitates reporting.
- Education and training that fosters behaviour change.
- Advances of technology that provides greater insight into fatigue risk on site.
- Data-driven approach to assessment of fatigue risk, contextualising relevance to specific site conditions, work environments and workforce demographics (i.e. work design).

Barriers to implementation of a FRMP (80):

- Effective application of a shared responsibility framework.
- Costs (financial, resource, time).
- Expertise required.
- Lack of leadership buy-in.
- Inability to achieve intended outcomes of the FRMP, e.g., sufficient oversight.
- Inability to make organisational changes in response to frequent reports.

Table 4 | FRMP characteristics as described by IPIECA (2019) (81).

Characteristic	Descriptor
Science based	Supported by established peer reviewed science.
Data driven	Decisions based on collection and objective analysis of data.
Cooperative	Designed together by all stakeholders.
Fully implemented	System-wide use of tools, systems, policies, procedures.
Integrated	Built into the corporate SHMS.
Continuously improved	Progressively reduces risk using feedback, evaluation and modification.
Budgeted	Justified by an accurate return-on investment business case.
Owned	Responsibility accepted by senior corporate leadership.

This approach aligns with the fatigue risk management processes outlined in other jurisdictions and is consistent with broader risk management practices applied across various industries (64) (10). This risk management component is also consistent with that described in QGN16.

However, despite the presumed familiarity with the risk assessment framework, a 2017 series of investigations by the Queensland Mines Inspectorate highlighted gaps in how fatigue was addressed within site SHMSs, particularly in relation to roster changes, contract arrangements, and work hours (33) and a Mines safety bulletin was issued with recommendations. These findings suggested that fatigue risk management may not be effectively implemented as intended. There may therefore be benefits that could be gained by enhancing industry competency in this area. This has been identified in other jurisdictions also. A Targeted Assessment Program undertaken at 15 open cut coal mines in NSW throughout 2017 and 2018 found risk assessments were not routinely conducted with someone sufficiently familiar with the fatigue risks on site (73). They also identified a lack of consultation with the workforce throughout the process.

IPIECA's Managing Fatigue in the Workplace guide for the oil and gas industry steps out the process for developing, implementing, evaluating and maintaining a FRMP (81).

7.2.1 Application of the hierarchy of control

The hierarchy of control (HoC) is a risk management framework that prioritises control measures to prevent and mitigate hazards in a structured order. It includes five levels:

- Elimination (removing the hazard entirely)
- Substitution (replacing the hazard with something less harmful)
- Engineering controls (isolating people from the hazard)
- Administrative controls (changing the way people work)
- Personal protective equipment (PPE) as the least effective option, used when other controls cannot fully eliminate the risk.

The goal is to reduce the likelihood of harm by applying the highest level of control that is reasonably practicable.

However, there are significant difficulties with applying the HoC to the implementation of fatigue controls. Fatigue cannot be entirely eliminated, as it is a physiological condition influenced by various factors like workload, shift patterns, and individual factors. Additionally, unlike physical hazards, fatigue is inherent in many work environments. As a result, lower order controls, typically administrative in nature, are predominantly relied upon to manage risk (23).

To add further complexity, some controls, like napping, can serve multiple purposes depending on the context. Napping could be viewed as an administrative control when it's part of a policy allowing rest breaks. However, if napping is integrated into shift design to reduce the need for extended wakefulness, it could also be seen as a substitution control, replacing a more fatiguing shift pattern with a less fatiguing one. The effectiveness and categorisation of a control often depends on how and where it's applied. This dual nature can make it challenging to clearly define where a control fits within the HoC, leading to potential inconsistencies in implementation.

In practice, fatigue management often requires a combination of controls that work together rather than a strict adherence to the hierarchical levels. This integrated approach can blur the lines between categories. Rather than rigidly categorising controls, the focus should be on understanding the context and effectiveness of each control within the broader fatigue management strategy. This might involve creating hybrid controls that draw from multiple levels of the HoC or developing bespoke strategies that recognise the unique aspects of fatigue as a risk factor.

An alternative way of thinking to the HoC, is the 'defences in depth' model, which describes five levels of hazard control (**Figure 22**). This model suggests fatigue-related incidents to be the end point of a sequence of a causal chain of events (20). Most organisations rely on controls that fall in the first and second level of the model (83). The value of this model is that it presents the hazards as part of a broader, integrated system; highlighting that implementation of controls at only one level (e.g., prescriptive hours of service) will not reliably prevent fatigue-related incidents (81). Organisations such as Queensland Health have adopted the defences in depth model for fatigue hazard identification and risk mitigation (59).

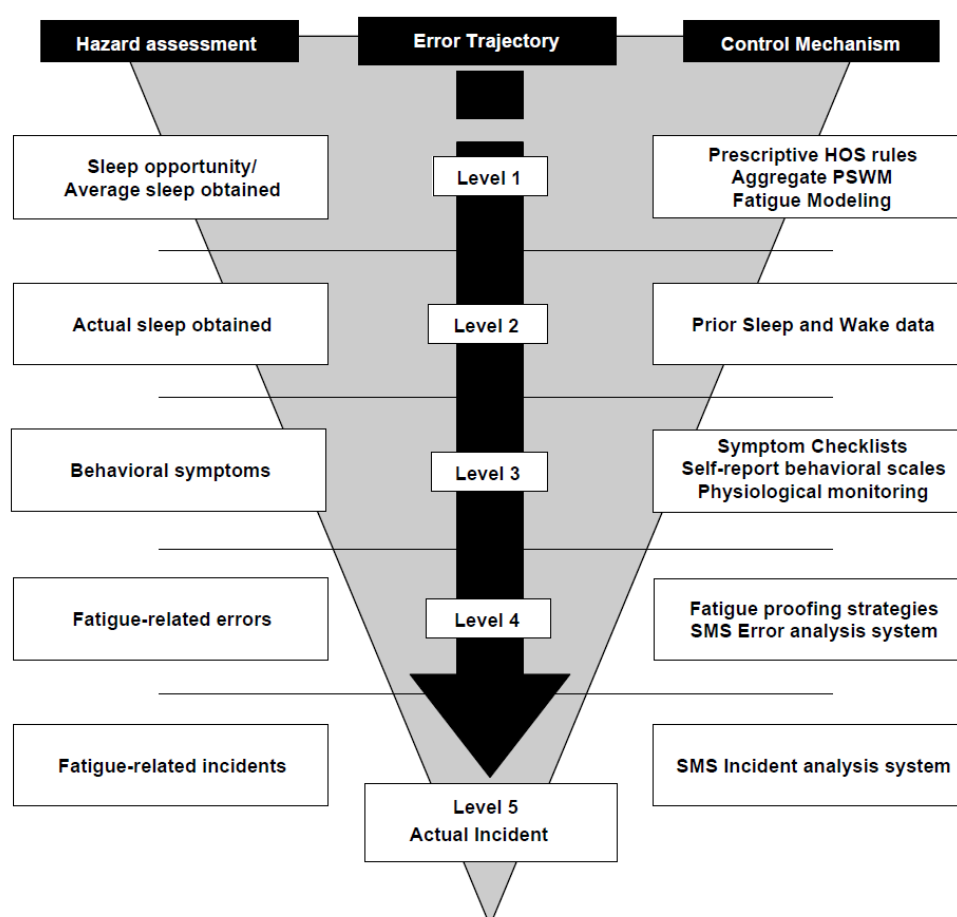


Figure 22 | The defences in depth fatigue risk trajectory as suggested by Dawson and McCulloch, 2005 (HOS: hours of service, PSWM: Prior sleep wake model, SMS: Safety management system) (20).

7.2.2 Reporting and investigations

Effective reporting mechanisms enable the timely identification and documentation of fatigue-related incidents, near-misses, and trends that could compromise safety. By encouraging transparent and regular reporting, organisations can gather valuable data that informs decision-making and proactive interventions. Findings from a 2023 survey across Queensland's mining industry, launched by the Commissioner for Resources Safety and Health, revealed that overly complex and unclear internal reporting mechanisms were an issue for 28% of workers who participated in the survey (84). Given the stigma associated with fatigue, underreporting of fatigue-specific incidents and hazards could be even higher.

Fear of reprisal was another significant sub-theme throughout the survey responses, with many workers indicating that either their own fear of reporting or observing fear experienced by others would impact their reporting behaviours (84). It is crucial that reporting systems are designed with a “no blame” approach, removing any fear of reprisal and ensuring that employees feel safe to report incidents without concern for negative consequences (82). Operators tend to rely heavily on worker self-reporting to manage fatigue risk on site (23). To ensure this mechanism remains effective, it is essential that organisations foster a culture where workers feel confident and supported in their reporting. This includes providing clear, accessible reporting channels, ensuring that reports are taken seriously and acted upon promptly, and continually reinforcing the importance of fatigue management through education and communication. A robust reporting culture is built on a foundation of strong leadership, where fatigue is recognised as an integral safety and health issue that requires input from all levels of the organisation to manage (82).

Finally, identifying when fatigue has played a role in an incident or near miss may require a thorough re-evaluation of investigation and reporting processes. This could involve adopting new methodologies to accurately assess fatigue as a contributing factor, enhancing training for investigators to recognise subtle signs of fatigue, and ensuring that reporting systems are robust enough to capture all relevant data. By doing so, organisations can gain deeper insights into the impact of fatigue on safety and take more effective measures to prevent future incidents.

7.3 Work scheduling

Work scheduling, including considerations of shiftwork, shift length, rest breaks, start times, rostering and shift rotation, may limit a worker's ability to adequately rest, contributing to fatigue (see [Section 5.2](#)) (10). Shifts and rosters should be designed, within the operational context of the site, to allow for adequate sleep opportunity and recovery time.

A participatory approach to establishing working patterns, where workers actively contribute to work design decision-making, can significantly reduce excessive sleepiness and perceptions of fatigue (8). When workers are involved in shaping their schedules, they are more likely to identify and propose adjustments that align with their individual sleep needs

More information and guidance on managing fatigue risk

IPIECA has published a series of information sheets on managing fatigue in the workplace (81). These provide general information on the hazard as well as strategies for the employer and worker to manage the risk. The information sheets cover the following topics:

- breaks
- managing driver sleepiness
- extended hours
- jet lag
- napping
- performance
- Ramadan
- sleep.

and personal circumstances, while still meeting operational requirements. This collaborative process fosters a sense of ownership and satisfaction, leading to better adherence to work schedules and fatigue management principles.

Ultimately, control measures should be implemented to ensure work schedules enable sufficient sleep opportunities. Work scheduling-related control strategies evaluated in the literature are listed below (**Table 5**). Many of these align with those captured in QGN16 and regulatory tools utilised in other jurisdictions. It's crucial to recognise that, given the subjective nature of fatigue, no single strategy can eliminate the risk. A combination of actions will be required to minimise risk. In some circumstances, a control may not be feasible for the site, in which case the SSE may elect to implement other controls to manage the acknowledged risk. This further highlights the need to consider fatigue from a systems perspective, utilising a risk-based approach rather than solely focusing on compliance.

Table 5 | Controls grouped by work scheduling factor.

Work scheduling factor	Controls
Shiftwork	<ul style="list-style-type: none"> Consider if night work is necessary (10). Avoid split shifts – if not possible, consider how they can be structured to minimise disruption on sleep (10). Provide alternative modes of transport, e.g., company bus from camp to/ from site (81). Schedule safety critical tasks outside the circadian trough (10).
Shift length	<ul style="list-style-type: none"> Fatigue risk correlates with shift length (i.e., a longer shift correlates with increased fatigue-related risk) (19) (23). Limit shifts to under ten hours (20). Limit overtime/maximum shift hours to ensure that the worker does not exceed 16 hours at work (including any commute) (20). As an example, the Fitness for Work Risk Register for a mineral mine in Queensland states ‘unplanned overtime cannot extend the working day beyond 14 hours.’
Rest breaks	<ul style="list-style-type: none"> Fatigue-related risk can be temporarily mitigated through the application of breaks across the shift, e.g., every two hours, particularly when combined with change in posture and/or social interaction (2). Some sites take advantage of this by providing additional crib breaks across night shifts (34). They also offer ‘fatigue breaks’ as required and at the discretion of the supervisor. Supervisors will then manage workers on an individual basis to determine causes of fatigue and how it can be managed. Allow sufficient rest between shifts. Research shows that less than 11 consecutive hours between shifts has a negative impact on fatigue, drowsiness and absenteeism (42). Allow sufficient rest (i.e., minimum 24 hours) after a sequence of consecutive night shifts (85). However, what constitutes <i>sufficient</i> will be determined by the cumulative sleep debt accrued. In the cases of acute sleep deprivation, where sleep debt occurs from one or two nights of insufficient sleep, the associated impairment can be rectified in only one or two nights of eight hours or more of sleep (SWA, 2013). However, in the case of chronic sleep deprivation, characterised by repeatedly achieving less than seven hours of sleep for multiple days, recovery can take up to a week of eight-hour daily sleeps.
Start times	<ul style="list-style-type: none"> Optimise shift start and end times to better align with circadian rhythms, e.g., start and end shifts around six or seven am rather than throughout the night (85) (10). Overlap consecutive shifts to allow adequate shift handover (10).

Work scheduling factor	Controls
Rostering	<ul style="list-style-type: none"> Where possible, analysis of fatigue risk informing scheduling should be conducted utilising biomathematical modelling and wrist actigraphy (2). This can be complimented by checklists and self-assessment surveys that prompt worker self-reporting and discussion with their supervisor. Relative risk increases by approximately a third (36%) between the third and fourth nightshift (17% increase for day shift) (44). This highlights the importance of limiting the number of consecutive night shifts to no more than three or four (85). In reality, it is not uncommon for sites to have limits on number of consecutive shifts of seven or more (23). Consider commute time as part of maximum allowable work hours. Select even-time rosters, with equivalent time on as off, as opposed to high compression rosters (4).
Shift rotation	<ul style="list-style-type: none"> Consider implementation of fixed roster patterns (47). If this is not an option, use forward rotating shift patters (i.e., morning, to afternoon, to night) as these are easier on the body's circadian system (85). A faster rotation (i.e., short roster length) is also generally better tolerated (8).

Some workplaces are taking scheduling a step further, utilising tools such as the Horne–Ostberg Questionnaire (HOQ) to better understand an individual's preferred times for waking up and going to sleep (16). Based on the responses, the HOQ classifies individuals into three categories: morning types (Larks), evening types (Owls), or those without a specific preference (indifferent types). This classification has then been used to assign individuals to shifts that best suit their natural preferences, enhancing productivity and reducing fatigue.

Contractors have been highlighted as a greater risk from a fatigue management perspective due to their unpredictable hours and regular movement between sites. It is important that the FRMP considers contractor fatigue management and incorporate systems to monitor contractor work hours. Some sites review a contractor's seven-day work history prior to allowing them on site. At an industry level, the coal industry has previously implemented a passport system for contractors moving between sites. Although this raised awareness of the total hours contractors were working, it relied heavily on an honesty system and was ultimately unsuccessful. With advances in technology, it has been suggested that **a similar system be explored again, potentially with the use of QR codes, however questions remain regarding responsibility for establishing and maintaining the required infrastructure**. Note the Coal Mining Safety and Health Advisory Committee have reportedly commenced work exploring this issue.



7.3.1 Planned vs actual

When examining fatigue management in the Queensland resources sector, the contrast between planned strategies and actual implementation reveals significant gaps that can impact worker safety and wellbeing. Operators may have comprehensive FRMP in place including work scheduling practices, rest periods, and monitoring systems designed to mitigate fatigue-related risks. However, in practice, these plans may not be fully realised due to several factors such as production pressures, staffing shortages, and the inherent challenges of a 24/7 operational environment.

In the NSW Targeted Assessment Program, several key issues were identified regarding fatigue management (86). Supervisors were found to routinely work more than 14 hours, directly breaching the established fatigue

management plan. Additionally, operators failed to adequately monitor whether minimum breaks and shift lengths were enforced, further compromising worker safety. Even when journey management plans were identified as a control, they were not consistently implemented, highlighting significant gaps between planned controls and actual practices in the field.

Scheduling has been combined with personnel tracking to further combat fatigue and contribute to understanding and addressing a lack of compliance with site fatigue management protocols. Electronic tagboards have traditionally been used to keep track of personnel in underground mines but are now also used to determine hours worked. This is particularly beneficial to provide data into planned versus actual scheduling.

7.4 Sleep hygiene

Risk is exacerbated by the quantity of sleep that the worker gets prior to starting work (20). As such, it is important to support the worker to achieve optimal sleep prior to starting work. Sleep hygiene refers to the environment, behaviours, and routines that occur prior to sleep (2). They can either enhance or impair sleep duration and quality.

Sleep hygiene strategies include:

- Maintaining a consistent sleep/wake cycle, particularly when sleeping in new environments, e.g., take a pillow from home to camp to simulate home sleep environment.
- Limit use of electronic media prior to bed as it displaces sleep (2).
- Reducing stimulants, such as caffeine and nicotine within four hours of bedtime or longer if sleep difficulties exist (2). Sleep problems have been found to be proportional to the quantity of caffeine consumed (22).
- Ensuring a dark, quiet bedroom, approximately 18-24°C (22).
- Avoiding consumption of large meals close to bedtime, as well as going to bed hungry, as both can disrupt sleep. Spicy meals, in particular, may exacerbate gastrointestinal issues. While not strictly a sleep hygiene practice, it's also important to note that providing healthy meals during shift work has been associated with reduced fatigue levels (8).
- Limiting alcohol. Alcohol may reduce the time it takes to fall asleep but increases wakefulness and suppresses REM sleep, especially when consumed within four hours of bedtime and in quantities of two or more drinks.
- Avoiding reliance on substances to manage sleep. Previous research has demonstrated that FIFO workers often use alcohol, sleeping pills, or other substances to manage the sleep pattern disruptions caused by shift work. (5). Developing a reliance on medication (either prescription or over the counter) for sleep disturbances should be avoided (2). They are typically intended for short-term use and can have negative side effects.
- Considering use of melatonin as directed by a medical professional. Melatonin can increase sleepiness and may be beneficial for resynchronising the circadian rhythm (2).

While sleep hygiene is crucial for individual wellbeing, it places the responsibility on the individual, rather the system as a whole. Sleep hygiene strategies are just one component of a comprehensive and holistic FRMP.

7.4.1 Exercise

Exercise offers well-established benefits for sleep quality, with laboratory studies showing that nighttime exercise can shift the circadian pacemaker, potentially aiding in the biological adaptation to shift work (37) (2). However, it's important not to exercise too close to bedtime, specifically within 3-4 hours of intended sleep, as this can negatively impact sleep onset (2). Aerobic exercise is particularly beneficial, improving sleep and enhancing adaptation to night work, provided it is not performed too close to bedtime (87).

7.5 Job demands

The type of work performed can have a significant impact on an individual's propensity to develop fatigue (36). Managing fatigue risk requires a focus on good work design principles, which ensure that job demands are balanced to maintain worker safety and productivity. This includes ensuring adequate and fit-for-purpose plant, machinery and equipment, limiting extended periods of excessive mental and physical demand, implementing job rotation where possible, and developing contingency plans for unexpected changes to work demands (10).

Several studies have examined the impact of increasing staff numbers during night shift to alleviate workload impacts on fatigue (8). However, this intervention was found to be ineffective at reducing fatigue, suggesting there are factors other than resourcing that have a greater impact on worker experience of fatigue.

7.6 Technology

Leveraging advanced technology has become a common strategy in enhancing fatigue risk management for sites. Organisations are increasingly utilising in-vehicle monitoring systems, wearables, and apps to enhance fatigue management and help ensure worker safety.

Automation is also gaining traction in the Queensland resources sector. This removes the human element from potentially hazardous work tasks, allowing workers to operate equipment remotely. For example, Thiess has a fleet of semi-autonomous dozers, autonomous haulage systems and autonomous drilling systems. These technologies have been reported to improve safety outcomes for the worker operating the systems from remote operating stations, while also improving fatigue risks.

Sleep banking – is it possible?

Sleep banking, also known as sleep accumulation, is a method where a worker will intentionally accumulate extra sleep before a period when they expect to get less sleep (100). In theory, the additional sleep achieved, builds up a reserve of rest they can draw from.

However, extended sleep contains less slow-wave activity (deep sleep), typically associated with recovery. This suggests extended sleep would have negligible impact on discharging sleep need and creating a positive sleep balance. Despite minimal slow-wave activity, it is possible that unknown neuronal networks are benefiting from the extended sleep. Further research is required.

7.6.1 In-vehicle monitoring systems

These systems work by monitoring specific biological and behavioural indicators of fatigue in drivers and applying specific actions to reduce driver fatigue and distraction events. Emerging technologies include in-seat sensors to monitor breathing and heart rate (e.g., Plessey monitors), camera systems that monitor driver body

movements (e.g., Guardian and the Valeo driver monitoring system), and artificial intelligence tools that learn driver behaviours to identify when drivers are operating outside their norm (e.g., Nvidia for Audi, Mercedes and Tesla) (52). These systems can also monitor vehicle operation such as speeding, acceleration, breaking, seat belt use, windscreen wiper use, GPS data and driving duration to paint a complete picture of fatigue events. A list of fatigue monitoring systems is provided below (**Table 6**).

Table 6 | *Fatigue monitoring systems described by Drews, et al., (2020) (9).*

Type of Technology	Description
Sleep pattern analysis using a smartwatch	Fatigue is predicted based on a biomathematical fatigue model and actigraphy-based sleep data.
Anti-drowsy alarm	This system raises driver awareness of momentary lapses caused by sleepiness. A device worn behind the driver's ear detects nodding movements and after crossing a threshold of the movement it emits an alarm sound.
Eyelid movement detection with infrared reflectance	Drowsiness or wakefulness is measured by a system that assesses infrared reflectance of the eye. Based on the reflectance data, eyelid movement is detected and used to assess eyelid closure. Other measures involve electro-oculography or video.
Electroencephalography (EEG) cap/helmet	This system uses a cap that has electrodes integrated to measure EEG. These measurements are used to recognise fatigue events.
Camera-based system	The system uses facial and eye recognition software to identify operator fatigue and to alert the driver if an instance of closed eyes for longer than a specific time was detected.
Fatigue warning kit	This system randomly emits a visual warning to which the operator has to respond by acknowledging the warning. Omission to do so activates a fatigue alarm.
Predictive and non-invasive monitoring	This approach uses a combination of two systems, one that is "knowledge-based" and provides an electronic template predicting hourly the likelihood of the driver falling asleep (circadian rhythm based), and the second using steering sensors to detect monotonous driving and steering movement characteristics to identify fatigued driving.
Pupillometer	This system uses a light that flashes through the viewer's eyes and assesses the pupil response to this stimulus (constriction and dilation). The pupil response time is used to assess driver impairment such as lack of sleep.

Since 2019, Glencore Coal Assets Australia has installed in-vehicle monitoring systems in 448 haul and water trucks across 11 sites in Queensland and New South Wales (88). Initially, these systems were used without driver alerts, allowing Glencore to collect baseline data on the frequency of eye closure events occurring on site. They then transitioned to full operation of the monitoring systems, including real-time alerts and the implementation of trigger action response plans (TARP) to effectively manage and respond to identified eye closure events. The TARPs include immediate actions to address fatigue-related risk as well as supports for longer-term fatigue management. Comparison of eye closure data across the years since implementation show a significant reduction in events, suggesting a reduction in fatigue risk across sites (**Figure 23**). Sites that have not reduced eye closure events across years were those that have not implemented TARPs, which support worker fatigue management following the event.

It is important to recognise that the Glencore case study provided above was specifically to address unintended distraction events (eye closure events) and not as part of an assessment of the workers' fatigue levels or fitness for work.

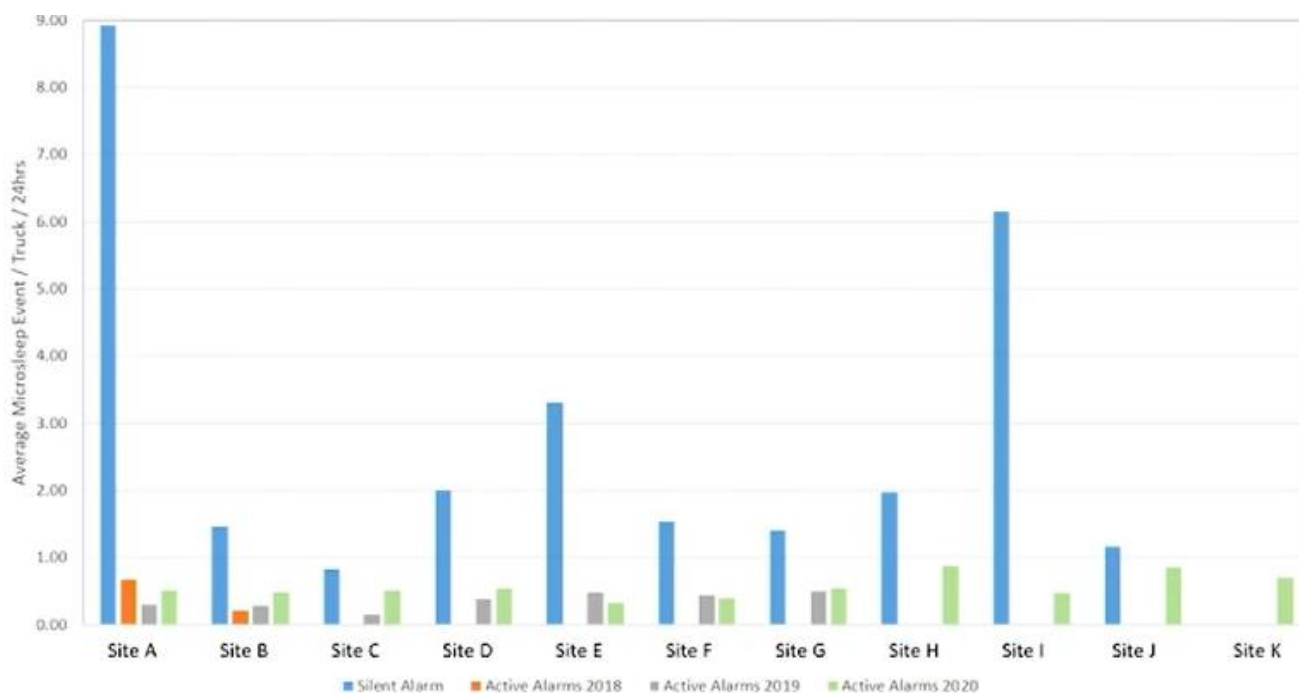


Figure 23 | Silent versus active alarm comparison across years (88).

Benefits of in-vehicle monitoring systems

- Provide objective information for risk assessments and incident investigations.
- Identifies specific individuals who are experiencing sleepiness and drowsiness. For example, at a Glencore site utilising this technology, 43% of their eye closure events were attributed to one operator (88). At the same site, 84% of events were attributed to only five operators.
- Providing footage to the individuals involved empowers the individual to take ownership of their fatigue management.

Limitations of in-vehicle monitoring systems

- These technologies are mitigating only, i.e., they contribute to the reduction of fatigue incidents but not the prevention of fatigue. As a result, some sites, have elected not to implement such systems.
- Concerns regarding privacy and acceptability by workers was cited as a significant barrier to implementation by industry at the *Fatigue Management Forum* in Emerald (28 May 2024).
- Requires robust Wi-Fi connectivity in the pit to enable timely notification of fatigue events (88).
- Operator complacency due to the presence of a fall-back (88).
- Can damage site culture and erode trust if not communicated effectively and transparently. Should be applied as a restorative rather than punitive measure.
- Lack of clarity around how monitoring integrates with safety systems and transparency around disciplinary measures (9).
- Complex technology, which is advancing rapidly and requires ongoing maintenance.
- Potential for false positives.
- Costly to purchase and install.
- Approach to alerting individual to the fatigue state (vibrating seat and/or auditory alarms) distracting (9).

In 2019, the NHVR commenced a trial to build their understanding of the characteristics, performance and utilisation of a range of fatigue technologies (89). The trial has relevance for how the heavy vehicle industry is applying these technologies to address fatigue risk. For their summary of the effectiveness of fatigue/distraction monitoring technologies see **Appendix D**. The review found that oculomotor measurement or face monitoring systems provided real-time monitoring of driver fatigue and offer most value to the user. However, further research is needed to ascertain their validity and reliability. The review also highlighted that these tools should not be used as a standalone tool for fatigue management, but as part of a FRMP.

7.6.2 Wearables

Wearable monitoring devices, a recent technology being implemented on some sites, offer real-time monitoring of heat stress and fatigue among workers (90). These devices are designed to detect changes in physiological states, such as heart rate variability, which may signal the onset of fatigue. By providing continuous, real-time data, they enable the timely removal of fatigued workers from hazardous areas and tasks before an incident can occur, enhancing overall workplace safety and reducing the risk of accidents. Limited information is available on the implementation of wearables across industry.

7.6.3 Mobile applications

Mobile applications can play a significant role in managing worker fatigue by integrating various data points, such as schedule information, time spent on site, fatigue assessments, and journey management plans. These applications collect and analyse data that is integral to enhancing and monitoring the effectiveness of a site's FRMP (90) (9).

For instance, SafetyIQ's Proactive Fatigue Management software features a game-like interface, engaging workers in a 60-second activity designed to assess psychomotor vigilance and cognitive readiness (91). Consistent use of the software at the commencement of each shift establishes a baseline for the individual. When results deviate from this baseline, it prompts a conversation between the individual and their supervisor.

As with other technological solutions, they should not be used in isolation, but part of the FRMP. More research is required to understand the reliability of these applications and validity in the field to reduce fatigue-related incidents.

7.7 Napping

Napping can be an effective fatigue management strategy if carefully managed. To maximise its benefits, it's crucial to consider the timing, length, and placement of naps within the circadian phase. Optimal nap duration should be either less than 45 minutes or longer than 110-120 minutes to avoid waking from slow wave sleep, which can exacerbate sleep inertia—a transitional period of grogginess that typically lasts about 35 minutes (52). Additionally, avoiding elevated levels of sleep deprivation can enhance the effectiveness of naps and ensure a smoother transition from sleep to wakefulness.

7.8 Environmental considerations

Exposure to humidity, heat, cold, vibration, poor air quality, and noise can increase the risk of fatigue, leading to faster exhaustion and impaired performance (23). Safe Work Australia (2013) describes several strategies to manage fatigue associated with site environmental conditions (10):

- Avoid working during temperature extremes and/or minimise exposure through job rotation.
- Provide a cool area for workers to take breaks and rehydrate. Provide education on the importance of hydration and self-pacing of work rate to match environmental conditions (23). However, self-pacing has only been found to be effective in reducing heat exhaustion risk in environments 30 degrees and under.
- Ensure sufficient ventilation and mechanical cooling.
- Provide adequate facilities for breaks, accommodation, etc.
- Address vibration issues, e.g., install low vibration seating in vehicles.
- Ensure the workplace is well lit (2).
- Ensure compliance with Personal Protective Equipment.

7.8.1 Light

The use of light is one of the most common tools utilised for managing fatigue attributed to circadian disruption (8). Exposure to light can have an immediate positive impact on mood and performance (16). The effects of light on circadian rhythms depend on its wavelength, timing, and intensity (2).

Several studies have explored the impact of light exposure on circadian phase re-setting (92). Increased illuminance in work areas during the night, particularly the early hours of the night, can delay melatonin production and reduce fatigue, stimulating a phase delay (92) (8). This same physiological mechanism can be used at other times of the day when required. Avoiding exposure to light in the morning before daytime sleep is crucial to prevent a decrease in melatonin levels due to light stimulation. Dugdale, et al., (2022) conducted a review of studies that tested the alerting effects of bright-light treatments (93). Studies where light treatment was delivered via fluorescent ceiling tubes in breakrooms demonstrated an attenuation in self-reported sleepiness (correlated with a reduction in melatonin secretion) compared with normal light conditions. The effects of bright light treatment were particularly relevant during the transition to night shift and readaptation back to day life. In both these situations, bright light therapy was found to facilitate subjective adaptation.

The wavelength of light can also impact its effect on fatigue, facilitating adaptation to shift work and improving overall performance. Light enriched with short wavelengths (i.e., blue light) induce more robust circadian phase resetting (92). The strategic use of artificial blue light in areas requiring high alertness can be beneficial. Several studies demonstrate a modest reduction in self-reported tiredness and improved cognitive performance following strategic exposure to blue light (94). Conversely, exposure to blue light should be avoided in the three hours prior to intended sleep. However, there is little evidence to suggest that these interventions reduce the long-term health consequences of night shift (38).

7.8.2 Camp environment

Anecdotal evidence indicates that the quality of worker accommodation varies significantly, not only between camps, but also within individual camps (45). This was highlighted at the *Fatigue Management Forum* in Emerald (28 May 2024) and emphasised again at the Mining and Energy Union 2024 *Site Safety and Health Representative Conference* (34).

Concerns regarding accommodation facilities centre around poor design that impacts sleep, shared facilities, isolation (lack of reliable access to internet and phone services), lack of recreation facilities, and poor quality of food provided. A notable issue for workers is the insufficient availability of beds before they commute at the end of their roster.



Resource companies are making changes to their accommodation villages to improve these issues. Enhancements implemented by companies like Arrow Energy and Anglo American Coal include the provision of health-care facilities, dietitian planned menus, improving the quality of furnishings in rooms, providing a well-equipped gym, and providing adequate and attractive entertainment areas for socialising.

Despite the issues, a 2015 survey of workforce accommodation arrangements in the Queensland resources sector commissioned by the Queensland Resources Council found that 82% of workers were satisfied with their accommodation arrangements and would not change, if given the option (45). This included workers living residentially as well as those undertaking long distance commutes. Overall, the survey highlighted positive sentiments among FIFO workers regarding their quality of life, health, and accommodation arrangements.

QGN16 includes a section on well-designed camps or residential accommodation, applying good design principles (40). More clarity and guidance also exists in other jurisdictions regarding the provision of worker accommodation. The *Workers' Accommodation Act 1952* (Qld) establishes minimum requirements and conditions for accommodation in sectors such as construction, meatworks, sawmills, sugar farms, and sugar works. However, no equivalent legislation exists for the resources industry in Queensland.

In Western Australia, the Department of Energy, Mines, Industry Regulation and Safety has issued guidance for employers on providing accommodation services, detailed in the Guidance for mine sites, exploration camps, and construction villages (95). This guidance outlines the standards and requirements that accommodation facilities must meet, including specific provisions for how the design and management of employer-provided facilities can contribute to management of fatigue and other fitness for work issues.

7.9 Education and competence building

Education and training are common fatigue controls implemented across the sector, particularly in coal where there is a legislative obligation to provide an 'education program' relating to personal fatigue (s. 42(2)(a) of the Coal Mining Safety and Health Regulation 2017 (Qld)) (23).

Learning and development opportunities are integral to cultivating a shared understanding of fatigue management and have been found to be effective for reducing fatigue when implemented well (8). Through tailored training and continuous education, operators and workers can better understand and adopt a shared responsibility framework for managing fatigue risk. When employers set policies and working time

arrangements, they should ensure workers are equipped with the competence to protect their own safety and health. Workers, empowered by education and training, are then able to use their time away from work to obtain sufficient sleep, present themselves as fit for duty, and comply with all relevant policies, procedures, and organisational requirements.

Core components of an effective education program include:

- education and awareness raising for worker, management, and families (2)
- developing adequate capability/competency in workers to recognise symptoms of fatigue and identify appropriate actions for fatigue mitigation (2) (10)
- delivering training for managers and supervisors to ensure they have the skills to take appropriate action when a worker is displaying symptoms of fatigue or makes a report of fatigue (fatigue-related impairment) (10).

7.10 A note on organisational culture

Effective fatigue risk management requires an organisational culture that prioritises safety, wellbeing, and open communication (13). This can be difficult in industries where long hours and high workloads are normalised, and where workers may resist or downplay fatigue-related issues due to perceived or actual productivity pressures. Workers, particularly contract workers, may also face coercive pressure to work extended hours to maintain job security, further complicating the implementation of effective fatigue management strategies.

It is important that the site culture encourages workers at all levels to recognise and report fatigue-related risks without fear of reprisal. Leaders play a crucial role in setting the tone by modelling healthy work practices, while also driving implementation and continuous improvement of the SHMS.

8.0 Conclusion

The review of fatigue management within the Queensland resources sector highlights the complexity and significance of fatigue as a critical risk factor impacting worker safety, health, and overall operational effectiveness. While substantial efforts have been made to manage fatigue risks, there are future opportunities, particularly in terms of enhancing the consistency of reporting and data, application of a risk-based approach to fatigue management away from prescriptive measures, and alignment with contemporary best practices for prevention and mitigation.

In moving forward, it is crucial to leverage the growing insights available through ResHealth and EOS to expand RSHQ's understanding for how fatigue impacts resources industry workers. Additionally, utilising Inspectorate initiatives, such as the petroleum and gas health projects, as a platform to engage with industry on fatigue presents a unique opportunity to gather valuable information, including outcomes from fatigue audits, current risk management practices (including application of emerging technology), and opportunities for improvement. This enhanced understanding will enable RSHQ to make informed decisions as a risk-based regulator for future regulatory activities.

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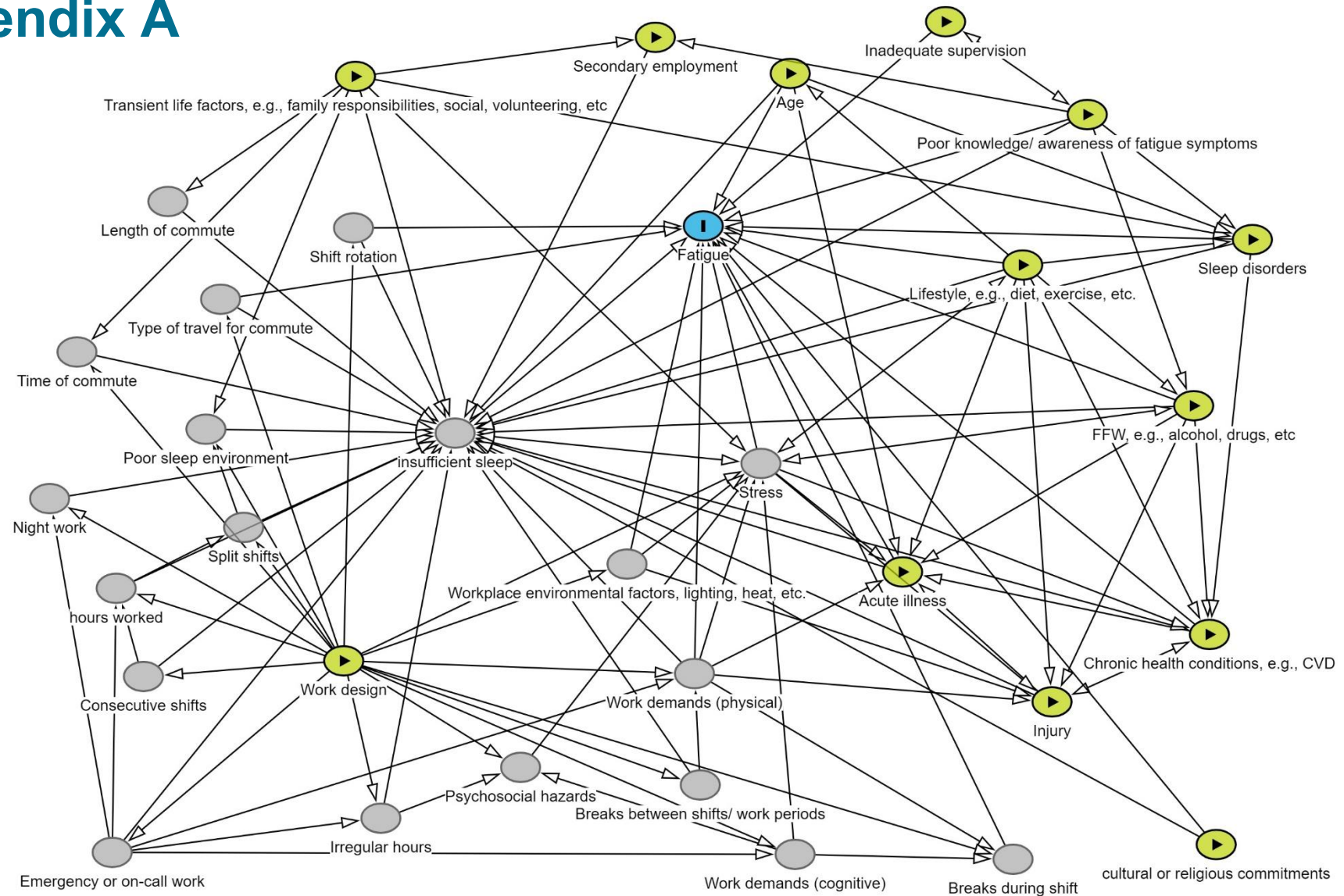
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Appendix A



Fatigue causality diagram, visualising the complex interplay of factors that can lead to fatigue. The blue icon indicates the outcome (fatigue), yellow icons indicate primary risk factors, and grey icons indicate ‘ancestor’ or subsequent risk factors contributing to fatigue.

Appendix B

A comparison of risk factors (i.e., conditions that increase risk of fatigue) for fatigue captured in QGN16 against those outlined in SWA's Guide for managing fatigue, including consideration for alignment with other regulatory and guidance material.

Risk factor	QGN16	SWA (10)	Other
Fatigue risk management plan or policy	Not in place	Not in place (10) (75) (96)	
Consecutive night shifts	>3	6 or more 8-hour shifts 5 or more 10-hour shifts 4 or more 12-hour shifts (75)	Any shifts ending between 00:00 and 06:00 (i.e., night shift) (ONRSR, 2020) 50% or more shifts end between 00:00 and 06:00 (ONRSR, 2020) >4 consecutive night shifts (97) Permanent night shifts (97)
Hours worked in a shift	>8 (8<10<12) (75)	>9 (>8 for night shifts) >9 hours (Commission for occupational safety and health, 2006)	9-hour maximum flight duty period in 24 hours (except if flight duty period commenced before 0600 or after 1400 in which case flight duty period must not exceed 8 hours) (CASA, 2021) >10 hours (ONRSR, 2020) >8 hours on night shift (97)
Hours worked in a week (day shifts)	>40	>40 (other than FIFO)	
Start times (day shift)	Before 6am		Before 6am (97) >4 successive early morning starts (i.e. before 6am) (97)
Commute times (daily)	>30 minutes	>60 minutes *SWA and WA includes commute in total work hours rather than as separate risk factor	>60 minutes (97) Start/finish times not convenient for public transport (97)
Commute times (pre and post work cycle)	>1 hour		

Risk factor	QGN16	SWA (10)	Other
Exposure to individual risk factors	Any FFW or health issues influencing sleep	Poor diet Recent illness/ injury Sleep disorders Influence of alcohol, drugs Inadequate time to fulfil family responsibilities Additional work commitments (second job) (96)	No consideration of individual differences and preferences (97) FFW: (97) Sleep disorders Alcohol use Drug use Illnesses impacting sleep Medication use Stress Personal factors (including family and social commitments, secondary employment/ volunteer work, physical activity) (97)
Regularity of hours	Irregular and unpredictable	Irregular and unpredictable	<24 hours' notice provided for any required night shifts (97) No monitoring system in place to determine the impact of unpredictable shifts to workers' personal lives and fatigue (97) No controls around hours of work for emergencies, when on call, or to cover unplanned leave (97)
Breaks during a shift	>3 hours between breaks on night shift; >5 hours on day shift and <30-minute main break	Infrequent	>3 hours for a minimum 15-minute rest break (64) <20min break every 5 hours (12)
Breaks between shifts/ work periods	Inadequate time (<8 hours high potential for fatigue)	Inadequate <48-hour break following a sequence of night shifts (75) specifies this is for FIFO)	Minimum 12 hours in any 24 hours (78) Minimum 36 hours (2 local nights) in any 7 days (78) <10 hours (64) <2 full nights of sleep provided after the last night shift (97) <7 continuous hours of non-work time (12).
Hours worked in 4-week period	>224		Maximum 100 hours flight time in 28 days (78)

Risk factor	QGN16	SWA (10)	Other
Type of work performed	Long periods of: <ul style="list-style-type: none"> mentally demanding monotonous tasks physically demanding work 	Highly repetitive work and/ or high concentration work over an extended period. Highly physically demanding work (75)	
Work environment	"Less than adequate control or high exposures to health hazards"	Exposure to hazardous environmental conditions: (75) (96) <ul style="list-style-type: none"> hazardous substances and atmospheric contaminants as determined by relevant exposure standards long periods of exposure to noise, extreme temperatures, vibration 	Excessive noise, poor lighting, vibration, temperature extremes, weather events, humidity (97)
Split shifts	Split shifts, particularly in safety critical tasks	Split shifts – 13-hour total period (75)	(97)
Seasonal work requirements (if role is busier during certain periods)	Peak seasons requiring additional hours worked/ overtime (75)		Inadequate resourcing (96)

Fatigue risk factors and management practices from other regulatory and guidance material that were not explicitly stated in QGN16.

Risk factor	Measure of highest risk
Total hours over three-month period (other than FIFO)	>624 hours (10) (75)
Total hours over three-month period (FIFO)	>728 hours (75)
Return from rest and recreation to FIFO operations	Inadequate sleep prior to first shift (75) Rostered on to night shift following a period of annual leave (97)
Sleep achieved	Day sleep rather than sleep at night (10) (75) < 8 hours in 24-hour period (10) (75) <8-hour sleep opportunity within 12 hours of commencing flight duty period or within 10 hours of commencing flight duty period away from home base (78) Recovery periods that do not preserve night sleep opportunity (i.e., recovery period outside 00:00 and 06:00) (64) Do not allow for 5 hours uninterrupted sleep in 24 hours (only for 1 night), AND enough time for 12 hours sleep in 48 hours, AND enough time for 50 hours sleep in 7 days (97)

Risk factor	Measure of highest risk
Psychosocial factors	Presence of psychosocial hazards (97) Working in isolation (96) Inadequate supervision (96) (75)
Extended wakefulness	Continuously awake for >17 hours
Shift rotation	Slower rotation (i.e., weekly/3-4 weekly) (10) (97) <i>Not</i> forward rotation (i.e., not moving from morning >afternoon > night) (SWA, 2013) (75) (97)
Fatigue monitoring	No system in place – reliance on self-reporting and administrative controls No systems/processes for workers who are fatigued at work (97) No health assessment/monitoring of worker health as it relates to fatigue (97) No controls or support for workers with known sleep disorders (97)
Consideration of fatigue around work scheduling	Within high-risk periods (circadian nadirs) Safety critical tasks/critical decision making occurring when workers fatigued (75) i.e., scheduled for night shift (97) Are complex physical or mental tasks undertaken on night shift? (97) Tasks requiring sustained physical or mental effort undertaken on night shift (97) No controls in place for when required to work during an emergency (97)
Accommodation facilities	Facilities not appropriate or available (23)
Shift end (night work)	After 10am OR before 6am (75) Night shift finish prior to 10.00am so day sleep not restricted? (97)
Training and information provision	Inadequate information and training provided (75) Supervisors and workers not trained in detecting signs of fatigue (97)
Incident investigation	The organisation's hazard and incident reporting and investigation system does not include consideration of working hours and fatigue (96)
Time on task	>85% of shift (64)
Consecutive shifts (any)	>2-4 between rest break of minimum 34 hours, including two-night sleep periods (ONRSR, 2020) Kept to a maximum of 5-7 days (97) More than 4 consecutive 12-hour shifts worked (97) More than 5 consecutive 10-hour shifts worked (97) More than 6 consecutive 8-hour shifts worked (97)
Shift swapping	Is shift swapping allowed (97)
Weekends	Not built into rosters or scheduled off work < every 3 weeks (97)
Pay incentives	Pay incentives for shift patterns or working practices that could increase the risk of fatigue (97)

Appendix C

How/where fatigue is captured across 'legislation and guidance material in multiple jurisdictions as compiled by Horberry, et. al., (2022) (23).

	Minerals			Transport		General Health & Safety	Offshore	Aviation	
State	QLD	WA	NSW	QLD		NSW	National		
Acts	Mining and Quarry Safety and Health Act 1999 / Coal Mining Safety and Health Act 1999 Captured under Safety and Health Obligations, Part 3	Work Health and Safety Act 2020 Captured under Division 2, Part 19, Primary duty of care	Work Health and Safety (Mines and Petroleum Sites) Act 2013 Captured in Work Health and Safety (Mines and Petroleum Sites) Regulations 2014	Transport Operations (Road Use Management) Act 1995 Captured in Transport Operations (Road Use Management—Fatigue Management) Regulation 2008	Heavy Vehicle National Law (Queensland) Captured under Chapter 6, Vehicle Operations – Driver Fatigue; Part 6.2, Duties relating to fatigue; Division 2, Duty to avoid fatigue; 228 <i>A person must not drive a fatigue-regulated heavy vehicle on a road while impaired by fatigue.</i>	Heavy Vehicle National Law (NSW) No 42a of 2013 Captured under Chapter 6, Vehicle Operations – Driver Fatigue; Part 6.2, Duties relating to fatigue; Division 2, Duty to avoid fatigue; 228 <i>A person must not drive a fatigue-regulated heavy vehicle on a road while impaired by fatigue.</i>	Model WHS Act 2022 Captured under Division 2, Part 19, Primary duty of care	Offshore Petroleum and Greenhouse Gas Storage Act 2006 Capture in Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009	Civil Aviation Act 1988 Captured in Civil Aviation Order 48.1 Instrument 2019
Regulations	Coal Mining Health and Safety Regulation 2017 Captured under Part 6, Fitness for Work; Division 1, General 42, Safety and health management for personal fatigue and other physical and psychological impairment, and drugs (see Appendix B) Mining and Quarrying Safety and Health Regulation 2017 Captured under Chapter 2 Parts 86 and 89 86 Worker’s self-assessment of fitness level. Each worker at the mine must periodically conduct a self-assessment of the worker’s condition, including, for example, for effects of heat strain or fatigue, to decide if the worker is in a fit condition to carry out the worker’s duties at the mine without creating an unacceptable level of risk. 89 Work hours and rest breaks. A mine’s safety and health management system must provide for controlling risk at the mine arising out of personal fatigue caused by excessive work hours or insufficient rest periods.	Work Health and Safety (Mines) Regulation 2022 Captured under Chapter 10, Mines: Part 10.2, Managing Risks; Division 3, Specific Control Measures – All Mines; Subdivision 3, Fitness for Work; 640, Fatigue In complying with regulation 617, the mine operator of a mine must manage risks to health and safety associated with worker fatigue.	Work Health and Safety (Mines and Petroleum Sites) Regulations 2014 Captured under Part 2, Managing Risks; Division 4, Specific Control Measures – All Mines and Petroleum Sites; Subdivision 3, Fitness for Work; 43, Fatigue In complying with clause 9, the operator of a mine or petroleum site must manage risks to health and safety associated with worker fatigue.	Transport Operations (Road Use Management—Fatigue Management) Regulation 2008 Captured under Part 2, Duties relating to fatigue; Division 3, Duty to avoid and prevent fatigue All parties in the chain of responsibility (including the driver) must take all reasonable steps to ensure a person does not drive a fatigue-regulated heavy vehicle while impaired by fatigue.	Heavy Vehicle (Fatigue Management) National Regulation 2018 Captured in Heavy Vehicle National Law (Queensland)	Heavy Vehicle (Fatigue Management) National Regulation (NSW) (2013 SI 245a) Captured in Heavy Vehicle National Law (NSW) No 42a of 2013	Model WHS Regulations 2022 Captured under Division 11, Psychosocial Risks; 55C Managing Psychosocial Risks A person conducting a business or undertaking must manage psychosocial risks in accordance with Part 3.1 other than regulation 36.	Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009 Captured under Chapter 3, Occupational Health and Safety; Part 1, Health and Safety; Section 3.1, Avoiding Fatigue The person must not allow, or require, a member of the workforce who is under the person’s control, to work for a duration that could reasonably be expected to have an adverse effect on the health or safety of the member of the workforce or other persons at or near the facility.	Civil Aviation Regulations 1988 / Civil Aviation Safety Regulations 1998 Captured in Civil Aviation Order 48.1 Instrument 2019
Recognised Standards / Code of Practice		Working Hours Code of Practice	Safety Management Systems in Mines: NSW Code of Practice		Master Code A registered industry code of practice under section 706 of the Heavy Vehicle National Law	Managing Psychosocial Hazards at Work: Code of Practice 2022 How to Manage Work Health and Safety Risks: Code of Practice 2018			
Guidance Notes	Queensland Guidance Note 16 (QGN16)		Fatigue Management Guidance for the NSW mining, petroleum and extractive industries	National Transport Commission (NTC) Guidelines for Managing Heavy Vehicle Driver Fatigue		Guide for managing the risk of fatigue at work	NOPSEMA Avoiding Fatigue Guidance Note		

Appendix D

NHVR summary of fatigue/distraction monitoring technologies (89).

Technology	Description	Fatigue/distraction technology devices	Effectiveness of technology devices
Fitness for duty tests	Tests are generally conducted before work to determine current alertness levels of drivers.	Variety of devices that assess worker/driver performance including vigilance or hand-eye coordination. For example, OSPAT. Not suitable for ongoing detection or monitoring driver fatigue within the heavy vehicle industry.	Not suitable for ongoing detection or monitoring driver fatigue within the heavy vehicle industry.
Continuous operator monitoring - Oculomotor measurements	Fatigue/distraction technologies based primarily on eye movements.	Optalert, CoPilot /DD850, Seeing Machines (DSS, Guardian), GuardVant (Opguard), LUCI, SafetyTrax DDM, Eye-Com, SmartEye, Blackbird Antisleep, DriveCam. Many oculomotor devices also detect driver distraction.	Many oculomotor devices also detect driver distraction. Only Seeing Machines technologies and Optalert had any third party assessments. Seeing machines (Guardian) have been implemented within the heavy vehicle industry.
Continuous operator monitoring – EEG - Electroencephalography	Fatigue detection based on brain wave activity.	SmartCap, B-Alert, WARDEN EEG type devices do not detect driver distraction.	Although evidence suggests EEG-type technologies do detect driver fatigue (albeit limited third party assessment) – EEG type devices do not detect driver distraction.
Other continuous operator monitoring technologies	Devices that continually measure physiological correlates of fatigue during work -	Posture/head nodding – Nap Zapper, Stay Awake, Driver Fatigue Alarm, NoNap, Dozer's Alarm, MicroNod, Travel Mate, Stay Alert. Galvanic skin resistance – (Engine driver vigilance telematics control system)	Although posture/head nodding type technology may be a predictor of driver fatigue, no third party assessments on the effectiveness of the technology for the heavy vehicle industry could be identified.
Performance based monitoring	Devices that monitor performance indicators that are associated with fatigue-related incidents.	Embedded performance measures – monitor task performance indicators associated with fatigue incidents (SafeTrak, MobilEye, AutoVue, Delphi, Maven Machines, CarVi, & Smartphone applications).	No current third party assessment of technologies. Limited assessed ability to predict driver fatigue and distraction, especially in the heavy vehicle industry.
Vehicle related technologies including crash avoidance technologies	Fitted vehicle safety technologies that aim to assist the driver to reduce the likelihood of a crash.	Crash avoidance technologies – Electronic Stability Control, trailer roll stability, autonomous emergency braking, electronic braking system, electronic brake distribution, adaptive cruise control, forward collision warning, lane departure warning.	Crash avoidance technologies do not provide any alert in relation to prediction of driver fatigue/distraction. Could be considered as an effective back-up to more driver predictive/monitoring technologies rather than the primary method to detect instances of driver fatigue.



Resources
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